# Ohio Department of Agriculture
# 2012 Final Report
# 12-25-B-1481

## Specialty Crop Block Grant - Farm Bill

**CONTACT**

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**Project Title: Expansion, Season Extension & Diversification of Brambles**

**Project Summary:**

The lead organization of this project is Ohio State University South Centers, 1864 Shyville Road, Piketon, OH 45661. The industry partners are Ohio Produce Growers and Marketers Association (OPGMA), 17 South High Street, Suite 200, Columbus, OH 43215, and Ohio Farm Bureau, 280 North High St, 6th floor, Columbus, OH 43215.

A comprehensive extension and research program was carried out by the project team from OSU South Centers in Piketon, Ohio. The project principle investigator Gary Gao reached at least 448 growers through fifteen presentations at various programs in Ohio. He also led research 8 tours, which drew 64 people. During the last two years, he made 62 farm visits. With the assistance of project team and staff members at OSU South Centers in Piketon, Gary Gao organized four major workshops that drew a combined attendance of 360. He and Ryan Slaughter completed three fact sheets that are entitled "Bramble Cultivar Guide," "High Tunnel Production Guide," and "Blackberry Production on Rotatable Cross Arm Trellis." Our press releases through OSU's Section of Communication and Technology had reached more than 1,000,000 readers. Our applied research demonstrated that high tunnel production of blackberries and raspberries can be a highly viable system for growers to reduce risks from adverse weather conditions and can extend harvest season by 2 to 3 weeks during the early and late parts of bramble harvest season. Yields in raspberries were not consistent due to poor weather conditions in 2013 and 2014. However, a raspberry grower with 27 acres was quoted in a newspaper article as having a 20% increase in 2013. Blackberry growers had one of the best years in 2013, if the blackberry plants did not have orange rust. However, the blackberry fruit harvest in 2014 was minimal due to polar vortexes. Even the most cold hardy blackberry cultivars only had less than 15% of their normal crop. An estimated 50 acres of blackberries and 10 acres of raspberries were planted during 2013 and 2014. Additional acreage will also be added in 2015 as a result of our research and outreach efforts. We estimated that at least 50 jobs could be created because of expansion of bramble production in Ohio. The project team has accomplished quite bit despite major weather related problems.

The proposed project was designed to address an urgent issue of a severe shortage of Ohio-grown blackberries and raspberries both in total quantity and seasonal availability. Fresh raspberry consumption was up nearly 300% in the United States (Dutch Rabobank, 2009). Drs. John Clark (University of Arkansas) and Chad Finn (USDA) wrote an article entitled Blackberry Crops Have Expanded Worldwide (Fruit Grower News, 2012). This strong demand for fresh blackberries and raspberries presented a “golden” opportunity for existing fruit growers to expand their production acreage and new growers to get into bramble production as a way to diversify their business. Our objectives were to increase the bramble production by at least 150 acres in the next 2-5 years, increase bramble yields by at least 15%, extend the bramble harvest season by at least 2 weeks, and create at least 50 jobs. No other grants were being sought for this project. The proposed project only benefited the bramble industry, not the competitiveness of any non-specialty crops.

**Project Approach:**

Applied Research Projects:

Several projects were conducted at OSU South Centers in Piketon. A winter hardiness study of blackberries was carried out where 4 Polish blackberry cultivars and three American blackberry

cultivars were compared side by side. A comparative study of high tunnel, rotatable cross trees and open field production system of blackberries was conducted. A high tunnel raspberry production trial and an open field raspberry production were carried out at OSU South Centers in Piketon in 2013 and 2014. Yield data and quality data were collected in 2013 and 2014. Research tours, workshops, presentations, grower visits, and email and phone consultations were our main ways of reaching both new and existing growers in 2013 and 2014.

**Goals and Outcomes Achieved:**

Expansion of Bramble Production:

There has been a strong demand for Ohio grown blackberries and raspberries. We initiated our research projects and outreach programs to help both new and existing bramble growers. We are very happy to report that quite a few growers either entered the bramble business as new growers while some existing growers expanded their berry operations despite adverse weather conditions in 2013 and 2014.

One of the brightest areas of bramble acreage expansion was blackberry production using rotatable cross trellis. At least 15 growers have planted blackberries in 2013 and 2014. Their new acreage ranged from 1 to 12. The total combined new acreage was estimated to be about 50. These plantings are scattered across the state of Ohio. The biggest blackberry planting is in southern Ohio. That farm planted 12 acres of blackberries in 2-13, making their total acreage to 22 acres. Another grower in southeast Ohio is planning on planting 3-4 acres in 2015. These blackberries plantings represented approximately a total of $1,000,000 in investments and potential gross revenue of $2,250,000, assuming an establishment cost of $20,000 per acre and $45,000 of gross revenue per acre.

An existing blackberry planting in southern Ohio.


A new 12 acre blackberry planting in Ohio in 2013.

New plantings of raspberries were difficult to track. Gary Gao has visited a few new and existing growers. Many existing growers have replaced part of their existing plants since a raspberry planting typically lasts about 10 years in Ohio. The estimated total of replacement and new raspberry planting was about 10 acres in 2013 and 2014.

Follow this link for an example of replanting:
http://www.ackermanberryfarm.com/History.html

Season-Extension Methods: A large number of high tunnels were installed in 2013 and 2014. However, we were not able to get the exact number for bramble production. Gary Gao had visited three growers using high tunnels bramble production in 2013 and 2014, gave a presentation on berry production in high tunnels at a high tunnel workshop at OSU South Centers to about 100 attendees in 2013. High tunnel bramble production received more and more attention from growers in Ohio. Several growers have started growing both blackberries and raspberries in high tunnels. There is still an excellent potential for high tunnel bramble production in Ohio. Those growers who used high tunnels for bramble production had achieved season extension, higher yields, and improved fruit quality. Due to polar vortexes in 2014 and more potential winter injuries, high tunnels and more winter hardy cultivars will be more essential than ever.
USDA Natural Resources Conservation Service has administered "The Seasonal High Tunnel Initiative," which is a voluntary program that provides financial and technical assistance to agricultural producers. According to Mr. T. J. Oliver of Ohio NRCS, 89 applications were approved in 2013 and 49 applied were approved in 2014. Some of these high tunnels were slated for bramble production. Many more high tunnels were built by Amish growers and English growers. The total number of high tunnels for bramble turned out to be way too hard for the project team to gather.

Season extension can be achieved by cultivar selection, mulch, shade, irrigation, low tunnels and high tunnels. Our other main method of season extension was cultivar selection.

A winter hardiness evaluation of blackberry cultivars was conducted from 2012 to 2014. Four Polish blackberry cultivars (GAJ, Polar, RUCZAJ, and 97521) and three American cultivars (Chester, Natchez, and Ouachita) were planted in 2012 and evaluated in 2013 and 2014. The Polish blackberry cultivar GAJ was the highest yielding cultivar in our trial and produced 7,969

lbs. per acre in 2013 while Chester produced 7,668 lbs. per acre (Table 1). In 2013, the other two Polish blackberry cultivars Polar and 97521 also had high yields of 4,682 and 5,534 lbs. per acre, while two American cultivars Natchez and Ouachita produced 5,968 and 5,785 lbs. per acre, respectively. RUCZAJ had the lowest yield of 2,050 lbs.

**Table 1: Winter Hardiness Season Yield Totals in 2013.**

| Cultivar | Marketable lbs. per plant | Marketable lbs. per acre | Average fruit weight (grams) |
|---|---|---|---|
| Chester | 13.2 A | 7668.1 A | 4.20 D |
| GAJ | 13.7 A | 7969.3 A | 6.07 C |
| Natchez | 10.3 B | 5967.6 B | 8.70 A |
| Ouachita | 10.0 B | 5785.3 B | 6.47 C |
| Polar | 8.1 B | 4681.9 B | 7.36 B |
| RUCZAJ | 3.5 C | 2049.6 C | 4.77 D |
| 97521 | 9.5 B | 5534.3 B | 4.55 D |
| **LSD** | **2.4434** | **1417.2** | **0.57** |

Treatments with the same letter are not significantly different.

After two polar vortexes in 2014, all of the blackberry cultivars were severely damaged. Chester, one of the most cold hardy blackberry cultivars, had a very modest crop of 1,005 pounds per acre (Table 2). Gai, a new Polish blackberry cultivar, had 733 pounds of blackberries per acre (Table 2). We can conclude that all blackberry cultivars tested in our trial were not cold hardy enough for the extreme low temperatures during the polar vortexes in 2014!

**Table 2. Winter Hardiness Season Yield Totals in 2014**

| Cultivar | Marketable lbs. per plant | Marketable lbs. per acre |
|---|---|---|
| Chester | 1.73 | 1,005.3 |
| Gaj | 1.26 | 733.1 |
| Natchez | 0.11 | 65.6 |
| Ouachita | 0.13 | 76.8 |
| Polar | 0.49 | 284.5 |
| Ruczaj | 0.28 | 162.0 |
| 97521 | 0.08 | 49.3 |

The low yields were due to low number of floricanes since all blackberry cultivars were floricane bearing ones (Table 3). The blackberry plants were able to produce a significant number of primocanes, which will be the fruit producing canes in 2015.

| Table 3. Average Number of Primocanes and Live and Dead Floricanes Recorded on July 18, 2014 | | | |
|---|---|---|---|
| **Cultivar** | **Avg. Primocane/Plant** | **Avg. Floricane/Plant** | **Avg. Dead Floricane/Plant** |
| Chester | 9.0625 | 1.875 | 1.0625 |
| Gaj | 12.5 | 2.8125 | 0.5625 |
| Natchez | 8.75 | 0.625 | 0.4375 |
| Ouachita | 11.6875 | 0.875 | 1.1875 |
| Polar | 11.625 | 1.5625 | 1.5 |
| Ruczaj | 10.0625 | 2.5 | 1.375 |
| 97521 | 7.625 | 0.1875 | 0.1875 |

We had also compared blackberries production systems, such as Rotatable Cross Arm Trellis (RCA), high tunnel and standard or open field on a two wire trellis. The study was more of an observation and demonstration, and was not replicated. But, it was still good to see that Natchez produced the largest fruits and highest yield of 7,380 lbs. per acre in 2013 (Table 4). Ouachita produced 3,231 lbs. per acre in high tunnel and 3,060 lbs. per acre on standard trellis (Table 4). Ouachita and Natchez on rotatable cross arm trellis did not produce much for us due to some management issues on our end.

| Table 4: Blackberry Yields of Three Production Systems in 2013 | | | |
|---|---|---|---|
| **Cultivar** | **Marketable lbs. per plant** | **Marketable lbs. per acre** | **Average fruit weight (grams)** |
| Ouachita RCA | 0.5 | 370 | 4.93 |
| Ouachita Standard Trellis | 4.2 | 3060 | 6.10 |
| Ouachita High Tunnel | 4.5 | 3231 | 6.79 |
| Natchez RCA | 1.8 | 1307 | 8.11 |
| Natchez Standard Trellis | 4.5 | 3247 | 7.51 |
| Natchez High Tunnel | 10.2 | 7380 | 8.79 |

In summary, several Polish blackberry cultivars showed excellent potential for high yields and good fruit size. These cultivars could be released by the nursery trade for commercial adoption. Natchez showed an excellent potential as a highly productive cultivar with very large berry size in high tunnels. Fruit growers in Ohio should look into high tunnel blackberry production using Natchez as a cultivar. Other cultivars can work in high tunnels as well. We were not able to include all of them due to limited funds.

Raspberries grew and produced very well for us in high tunnels. Cultivars tested were Caroline, Heritage, Himbo Top, and Joan J. There were 4 replications of these four cultivars inside a high tunnel and outside in an open field. Each experimental plot measured 3 feet wide by 6 feet long. There were 3 raspberry plants per plot and they were spaced 2 feet apart at planting. All raspberry planted were planted on raised beds. Since all four raspberry cultivars tested were everbearing type, they suckered freely and formed a hedge rather than stayed as individual plants. Hence, total yields per plot of 3' x 6' were recorded.

Our high tunnel was a Gothic style FarmTek Tunnel that measured 30’ wide by 36' long, and 14' high with fabric drop down sides. Raspberry bushes were planted in May, 2013. The high tunnel was installed in October, 2013. Detailed raspberry yield data were collected in 2014 since this was the only year that our raspberry tunnel was in place for the entire growing season.

Pictured here is a new gothic style high tunnel being assembled for our raspberry season-extension project. The high tunnel installation was completed in October, 2013.

Our completed high tunnel with raspberry plants on June 4, 2014.

All four of the raspberry cultivars in our trials had higher yields during the first three weeks of harvest (Table 5). Joan J., Himbo Top and Caroline had higher yields during the first three weeks than Heritage in high tunnel when compared to open field. Joan J. had the highest earlier yields among all four cultivars while Himbo Top was a close second. Caroline ranked third out of four cultivars while Heritage was a distant fourth.

If raspberry growers can get a high premium for earlier raspberries, high tunnel raspberry production can make a lot of sense. Caroline, Himbo Top and Joan J. can all work since their

yields and fruit quality are different. All of these three cultivars are new while Heritage has been an industry standard for about 50 years.

**Table 5. Weekly Yield Data of Four Raspberry Cultivars in a High Tunnel and Open Field in 2014.**

| Production Systems | Cultivars | WEEK 1 (g) | WEEK 1 (LB) | WEEK 2 (g) | WEEK 2 (LB) | WEEK 3 (g) | WEEK 3 (lb) |
|---|---|---|---|---|---|---|---|
| High Tunnel | Caroline | 434 | 0.96 | 420 | 0.93 | 886 | 1.95 |
| High Tunnel | Heritage | 16 | 0.04 | 35 | 0.08 | 255 | 0.56 |
| High Tunnel | Himbo Top | 694 | 1.53 | 1223 | 2.70 | 1258 | 2.77 |
| High Tunnel | Joan J. | 773 | 1.70 | 1615 | 3.56 | 1832 | 4.04 |
| Open Field | Caroline | 86 | 0.19 | 143 | 0.32 | 422 | 0.93 |
| Open Field | Heritage | 4 | 0.01 | 24 | 0.05 | 214 | 0.47 |
| Open Field | Himbo Top | 226 | 0.50 | 195 | 0.43 | 223 | 0.49 |
| Open Field | Joan J. | 94 | 0.21 | 383 | 0.84 | 1126 | 2.48 |

During the weeks 4 through 8, the yields in open field "caught up" with those in the high tunnel (Tables 6 and 7.) The results validated the theory and findings from other reports that high tunnels promote early fruit ripening.

**Table 6. Weekly Yield Data of Four Raspberry Cultivars in a High Tunnel and Open Field in 2014.**

| Production Systems | Cultivars | WEEK 4 (g) | WEEK 4 (lb) | WEEK 5 (g) | WEEK 5 (lb) | WEEK 6 (g) | WEEK 6 (lb) |
|---|---|---|---|---|---|---|---|
| High Tunnel | Caroline | 1552 | 3.42 | 1746 | 3.85 | 1454 | 3.21 |
| High Tunnel | Heritage | 528 | 1.16 | 758 | 1.67 | 1112 | 2.45 |
| High Tunnel | Himbo Top | 1454 | 3.21 | 1242 | 2.74 | 824 | 1.82 |
| High Tunnel | Joan J. | 1238 | 2.73 | 1248 | 2.75 | 764 | 1.68 |
| Open Field | Caroline | 1176 | 2.59 | 1516 | 3.34 | 1900 | 4.19 |
| Open Field | Heritage | 594 | 1.31 | 934 | 2.06 | 1148 | 2.53 |
| Open Field | Himbo Top | 744 | 1.64 | 1008 | 2.22 | 822 | 1.81 |
| Open Field | Joan J. | 1748 | 3.85 | 1712 | 3.77 | 1698 | 3.74 |

**Table 7. Weekly Yield Data of Four Raspberry Cultivars in a High Tunnel and Open Field in 2014.**

| Production Systems | Cultivars | WEEK 7 (g) | WEEK 7 (lb) | WEEK 8 (g) | WEEK 8 (lb) |
|---|---|---|---|---|---|
| High Tunnel | Caroline | 1478 | 3.26 | 498 | 1.10 |
| High Tunnel | Heritage | 1068 | 2.35 | 502 | 1.11 |
| High Tunnel | Himbo Top | 550 | 1.21 | 268 | 0.59 |
| High Tunnel | Joan J. | 1002 | 2.21 | 572 | 1.26 |
| Open Field | Caroline | 1486 | 3.28 | 720 | 1.59 |
| Open Field | Heritage | 1092 | 2.41 | 746 | 1.64 |
| Open Field | Himbo Top | 464 | 1.02 | 438 | 0.97 |
| Open Field | Joan J. | 1352 | 2.98 | 544 | 1.20 |

**Table 8. Seasonal Total Yields of Raspberry Cultivars in High Tunnel and Open Field in 2014**

| Production Systems | Cultivars | Total Season Wt. (g) | Total Season Wt. (lb) | Soluble Solids %Brix |
|---|---|---|---|---|
| High Tunnel | Caroline | 8468 | 18.69 | 9.29 |
| High Tunnel | Heritage | 4274 | 9.42 | 9.99 |
| High Tunnel | Himbo Top | 7513 | 16.56 | 9.27 |
| High Tunnel | Joan J. | 9044 | 19.94 | 9.60 |
| Open Field | Caroline | 7449 | 16.42 | 9.60 |
| Open Field | Heritage | 4756 | 10.49 | 9.99 |
| Open Field | Himbo Top | 4120 | 9.08 | 9.53 |
| Open Field | Joan J. | 8657 | 19.09 | 9.14 |

Seasonal yield totals were not very different for Heritage and Joan J. in high tunnel compared to open field (Table 8). Caroline seemed to be slightly productive in high tunnel when compared to open field. Himbo Top benefited the most from high tunnel among all four cultivars tested in our trial. The total average yield went from 9.08 pounds per plot to 16.56 pounds, an 82.4% increase! It would make quite bit sense for growers to grow Caroline, Himbo Top, and Joan J. in high tunnels in terms of early ripening. However, in terms of both early ripening and seasonal yield differences, Himbo Top might be best suited for high tunnel production. The soluble solids contents were only tested once and were not very different since we only harvested ripe fruits on the weekly basis.

It would make sense to follow the yield trends in 2015 to see if there is a significant difference in fruit production on floricanes in high tunnel vs. open field. It is also a good idea to see how

much season extension can be achieved in autumn. We observed at least 4 additional weeks of fruit production in high tunnel when compared to open field. Growers are encouraged to utilize high tunnels in both blackberry and raspberry production on a small scale to see if early ripening and/or yield increases could turn into high profits.

Yield Increases in Bramble Production: Yield increases were not achieved due to a late freeze in spring of 2013 and two "polar vortexes" in 2014. The yields of brambles are determined by many factors, such as weather, soil conditions, cultivars, pest control, pollination, irrigation, fertilization, and pruning.

A late freeze in 2013 damaged a lot of floricanes in raspberries. Floricanes are the canes that produce fruits in summer red and black raspberries. Most growers in Ohio had either an average or a below-average crop in 2013. However, one large grower experienced a 20% increase according to an article in Springfield News-Sun on June 15, 2013. For more information, please refer to the news article online at http://www.springfieldnewssun.com/news/business/crop-and-anxieties-up-as-raspberry-season-opens/nYJ5z/

In 2014, two polar vortexes caused at least a yield reduction in raspberries, especially in black raspberries. Primocane bearing raspberry cultivars did okay in the field. As more and more these unpredictable weather events occur, growers in Ohio may need to look into high tunnel protection for dependable raspberry production. There have been some advances in raspberry breeding work. However, the improved cultivars may not consistently yield enough raspberries every year. Hence, raspberry production under a protected structure of some sort may still be the way to go.

Blackberry production in Ohio experienced two extremes in 2013 and 2014. In 2013, many growers had a very high yield on their blackberries. This is assuming that their blackberry plants did not have any orange rust. Before orange rust and the cold winters Chester planted at 14 ft. wide and 6 feet between plants would yield 8,000 to 12,000 lbs per acre. Theoretically, Triple Crown could yield about 6,000 to 10,000 lbs. per acre. Orange rust could reduce the yield by about 50%. In 2012 and 2013, growers who had orange rust in their planting produced about 3,180 lbs. per acre. Total yields in blackberries in Ohio ranged from 3,180 to about 8,000 lbs per acres.

In 2014, blackberry production in the open fields was "wiped out" by two polar vortexes since pretty much all of our blackberry cultivars are floricane types. The quality of primocane types was not quite good enough yet for commercial production. In addition, the growing season in Ohio is not long enough for a profitable fall bearing blackberry production.

Based on our research data, grower experience, unpredictable weather patterns in Ohio, and development of new production techniques, we strongly encourage our growers to consider growing blackberries and raspberries in protected systems. With blackberries, the two good options are Rotatable Cross Arm trellis and high tunnels. With raspberries, high tunnels might be the main good option, if growers desire consistently high yields year after year.

Grower Outreach:

Grower Outreach in 2013 and 2014

Presentations:

Dr. Gary Gao served on an Expert panel during the 2013 Ohio Produce Growers and Markets Association Congress and answered growers' questions on bramble production. He gave a talk on fertility management of berry crops at the "High Tunnel Production Workshop" at OSU South Centers. He organized a "Commercial Berry Production Workshop." He gave a talk on "Blackberry Production Systems," and demonstrated how to prune blackberry plants. These two programs drew a combined audience of approximately 200.

A "Berry Production School" was offered in Medina on April 23rd. The program drew 12 attendees. Dr. Gao presented his research findings on blackberry and raspberry production there. He gave a talk on commercial blackberry production to 52 farmers at the 2013 Farm Science Review. In addition, Dr. Gao severed as a panel member on a "Question the Authority" session at the 2013 Farm Science Review where he talked about opportunities in fruit production.

In 2014, regional and statewide berry production workshops were held in northwest Ohio (Fulton County), southwest Ohio (Montgomery) and central Ohio (Logan County) and Southern Ohio (Ohio South Centers in Piketon). These workshops drew a combined attendance of 184.

Gary Gao gave a representation on "Opportunities in Commercial Raspberry Production in Ohio" at the 2014 Farm Science Review, and one presentation on fruit production at the Franklin County Urban Farm program. These two presentations drew a total of 81 attendees.

Research Plot Tours:

In 2013, a research tour was given to Dr. Bruce McPheron, the Dean of College of Food, Agricultural and Environmental Sciences on April 2. Another tour was given to a group of OSU Extension educators and specialists. Gary Gao provided a tour of the research plots to the members of the Liaison Committee at OSU South Centers. These research tours drew a combined attendance of 45.

A research tour was given to a family of 4. The family was planning on a planting of 2 to 3 acres of fruit production. Two more tours were given to researchers at Ohio State and the members of liaison committee for OSU South Centers. These tours attracted 20 attendees.

Grower Visits:

In 2013, Gary Gao visited Moreland Fruit Farm and Maurer Berry and Vegetable Farm on April 3 and 4 in Wooster, Ohio. He also diagnosed problems for a blackberry farm on June 12 in Milford, visited a raspberry farm on June 14 in Mansfield and a raspberry farm on June 19 in Thornville. He visited a potential bramble farm site at Granville on June 19. The landowners planted 2 acres of blackberries and raspberries in 2014. Gary Gao visited five raspberry farms and a blackberry farm in July and August. These bramble farms represented a total acreage of at least 50.

In 2014, Dr. Gary Gao made 12 grower visits across Ohio. He met with both new and existing growers. These visits represented approximately 40 acres of bramble production. Several families are planning on planting 2-5 acres of brambles 2015.

Educational Programs at OSU South Centers in Piketon:
We organized "Ohio Berry School," and "Ohio Blackberry, Blueberry and Wine Grape Field Night" in 2013 and 2014. These two programs drew approximately 360 attendees.

Applied Research at OSU South Centers in Piketon:
Our research crew finished the installation of two raspberry plots. A high tunnel has been placed over one of our raspberry plots. These plots will be featured in 2014 field nights and educational programs.

Many of the new varieties in our trial look promising. We are very excited about Joan J. It is one of the very few true thorn-less red raspberries cultivars available in the commercial trade. Yield and quality attributes have been reported to be quite good. We are very anxious to find out how well this variety will perform in Ohio.

Our research crew also harvested blackberries from our plots and collected yield data. This year (2013) has been an excellent year for blackberry production. Yields were quite high on many varieties. Fruit quality data have been collected from the samples stored in our freezer. Both yield and fruit data will be analyzed in the winter months in 2014. It is good that growers have more choices

'Natchez' is a new blackberry cultivar with very large and tasty fruit.

Job Retention and Creation:
The bramble production is a very labor intensive operation. In 2013, blackberry growers experienced an excellent year. The yields varied from 3,100 lbs. to about 10,000 per acre. With 235 harvested acres (USDA 2012 Ag. census) in blackberry production, the value of the blackberry crop can range from $2,428,333 to $7,833,333, assuming a retail price of $5.00 a quart or $3.33 a pound. Blackberry production in 2013 could translate into retention of approximately 100 to 250 jobs. With addition of 50 acres of blackberry production on rotatable cross arm trellis, the potential impact can be around $2.25 million, assuming gross revenue of $45,000 per acre. The increased acreage blackberry production can translate into approximately 50 jobs.

In 2013 and 2014, raspberry yields were estimated to be between 2,000 to 4,000 pounds per acre. With 309 acres of harvested raspberries in 2012, it can be estimated that the raspberry production in Ohio represented an economic impact of $1,854,000 to $3,708,000 each year in 2013 and 2014. It is safe to assume that raspberry production in Ohio represented retention of at least 50 to 100 jobs. At least 2-3 additional jobs can be generated through 10 acres of new raspberry planting.

In summary, more than 150 to 300 jobs were estimated to be retained by blackberry and raspberry production and more than 50 jobs were projected to be created due to expansion of blackberry and raspberry production in Ohio.

Farm Diversification:
Based on the 2012 USDA Ag. Census, there were 415 blackberry farms and 405 raspberry farms. Some of these farms probably grew both blackberries and raspberries. Gary Gao had visited quite a few of them. However, he wasn't able to find all of these small plantings since there were all scattered all over the state. There were not required to report any product data to anyone. It is still reasonable to assume that at least 50 small-scale farms had added blackberry or raspberry to their farming operations during the last two years. Some of these plantings ranged from just a few rows to an acre or two.

Grower Publications:
New Extension Publications/Fact Sheets:
Gary Gao and Ryan Slaughter. "Bramble Cultivar Guide for Ohio." 2014. OSU South Centers, Piketon, Ohio.

Gary Gao and Ryan Slaughter. "High Tunnel Bramble Production Guide for Ohio." 2014. OSU South Centers, Piketon, Ohio.

Gary Gao and Ryan Slaughter. "Growing Blackberries on Rotatable Cross-Arm Trellis in Ohio." 2014. OSU South Centers, Piketon, Ohio.

Videos: (Uploaded to OSU South Centers' YouTube channel)
Gary Gao and Duane Rigsby. "Blackberry Production in Ohio." 2014. OSU South Centers, Piketon, Ohio.

Gary Gao and Duane Rigsby. "Raspberry Production in Ohio." 2014. OSU South Centers, Piketon, Ohio.

Trade Magazines:
Blackberry & Raspberry Production in Ohio. June, 2014. OPGMA Today, a quarterly publication of Ohio Produce Growers and Marketers Association. Columbus, Ohio.

Extension Newsletters:
“Ohio Fruit News” - Several issues of the Ohio Fruit News were published in 2013. Ohio Fruit News was emailed to about 350 subscribers.

Website:
OSU South Centers Website - Our website was redesigned. We had a page for commercial blueberry production. Currently, the information is not complete. We will add more information to the page.

**Beneficiaries:**
All of the existing blackberry and raspberry farmers on at least 415 blackberry farms and 405 raspberry farms have benefited from our research and extension efforts. Many members of Ohio Produce Growers and Marketers Association and Ohio Farm Bureau Federation also benefited from this project. There were also new growers who entered into bramble production. Due to high costs of bramble establishment, most new growers seemed to have pretty good credit and some cash reserve. Consumers in Ohio were also beneficiaries of our project since many of them got to enjoy Ohio grown fresh blackberries and raspberries.

**Lessons Learned:**
We have learned quite a few lessons from this project. First is that adverse weather conditions can still have serious consequences on both blackberry and raspberry production. Second, statewide data on bramble yields and profit margin were way too hard to collect. Third, bramble production is both labor and capital intensive. Addition of new bramble plantings requires only large capital investment, but also a lot of time for growers to digest production and marketing formation.

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**Additional Information:**
Press Releases or News Articles:
http://oardc.osu.edu/7328/Blackberries-Hold-Potential-to-Increase-Farm-Profits-Learn-How-at-Farm-Science-Review.htm

http://www.agriculture.purdue.edu/AgAnswers/story.asp?storyID=6746

http://www.growingproduce.com/fruits-nuts/berries/boosting-berry-production-in-ohio/

https://www.oardc.ohio-state.edu/7310/Blueberry-Blackberry-Wine-Grape-Field-Night-is-July-18.htm

http://www.thegrower.com/news/Ohio-researchers-seek-hardier-blackberries-159103175.html

http://cfaes.osu.edu/news/articles/blackberries-hold-potential-increase-farm-profits-learn-how-farm-science-review
"Blackberries Hold Potential to Increase Farm Profits: Learn How at Farm Science Review"

"Cold weather a concern for fruit growers." February 6, 2014. Ohio Country's Journal. The article is available online at http://ocj.com/2014/02/cold-weather-a-concern-for-fruit-growers/

"Blueberry, Brambles and Winegrape Field Night July 15." July, 2014. Ohio Country's Journal. http://ocj.com/2014/07/blueberry-brambles-and-winegrape-field-night-july-15/

"Berry Good" by Jill Sell. August, 2014. Ohio Magazine. The article is available online at http://www.ohiomagazine.com/main/Articles/Berry_Good__4988.aspx

"Berry Bonanza" by Jill Sell. August, 2013. Ohio Magazine. The article is available online at http://www.ohiomagazine.com/Main/Articles/Berry_Bonanza_4815.aspx

Gary Gao was interviewed by a reporter with Ohio Magazine for an article on blackberries that will be published in August.

An example of Ohio Farm Bureau Event:
https://ofbf.org/uploads/YAP_SummerEvent_webMay620131.pdf
Stokes Berry Farm (42 aces of blackberries and 6 acres of red, purple and yellow raspberries.)

An example of high tunnel and field raspberry production farm in Ohio:
http://www.annsraspberryfarm.com/gallery?page=1

An example of a new berry farm in Adams County, Ohio
https://www.facebook.com/bdberryfarm/timeline?ref=page_internal

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**Project Title: Suppression of Escherichia coli O157:H7 by Ohio Specialty Crop Soils**

**Project Summary:**
Foodborne pathogen persistence in soil is a fundamental knowledge gap to the production of safe vegetables and small fruits. Successful interventions that reduce pathogen survival in soil would have positive impacts on food safety by minimizing contamination entering the processing stages. The purpose of this project was to determine the effect of soil pH, moisture content, and soil organic matter (SOM) on the survivability of our model foodborne pathogen, E. coli O157:H7, in the soil and to quantify suppressiveness of soils used to grow vegetables to the proliferation of this foodborne pathogen.

The project was timely because bacterial contamination of raw fruits and vegetables continues to be a growing issue for food safety. Through this project, we have gained critical information required to develop control measures leading to proactive efforts by Ohio farmers to enhance food safety. This will translate into increased consumer trust in the small fruits and vegetables produced in Ohio and increased sales.

This project did not build on a previously funded SCBGP project; however, the microbial community profiling methods will support a recently funded SCBGP project titled "Validation of waiting intervals for the incorporation of untreated biological soil amendments into soil where specialty crops are grown in Ohio" (LeJeune FY2013 and 2014). The Ohio State University and the Ohio Produce Growers and Marketers Association have collaborated on this project.

Foodborne pathogens in the soil can contaminate vegetables via rain splash and possible uptake through the roots. Successful interventions that reduce pathogen survival in soil and would therefore have positive impacts on food safety. The purpose of this project was to determine the effect of soil pH, moisture content, and soil organic matter (SOM) on the survivability of our model foodborne pathogen, E. coli O157:H7, in the soil and to quantify suppressiveness of soils used to grow vegetables to the proliferation of this foodborne pathogen. Our hypothesis was that specific microbial populations are naturally present in Ohio soils where specialty crops are grown that are inhibitory to foodborne pathogen survival.

**Project Approach:**

Specific Aim 1: A longitudinal survey was conducted to determine the frequency and extent to which soils from different fields suppress colonization and survival of foodborne pathogens, specifically E. coli O157. For Specific Aim 1, we completed all field-based soil collection and suppression assays in Year 1 (2013). We collected soil at planting and during harvest from 12 different fields growing tomatoes or lettuce in central and northern Ohio. Soil samples were assayed for anti-E. coli O157 effects by inoculating either heat-treated or unheated soil with a green fluorescent protein-labelled E. coli O157 strain and following the fate of these bacteria over time. In addition, levels of pH, moisture content, and organic matter were determined for each sample.

We found that:

•Removal of the soil microflora through heat-treatment decreased the suppressive capacity of the soil indicating that the suppression was biologically based.

•When the E. coli counts were normalized for the suppressive effect related to the chemical parameters alone, fields from the central region of Ohio showed the highest relative suppression compared to those fields from the northeast or north-central regions.

•Soil pH, moisture content, and organic matter levels varied widely within and across the three regions.

•There was a significant correlation between SOM and moisture content and SOM was the most important chemical parameter to predict E. coli survival.

Specific Aim 2: In order to understand the abiotic basis for pathogen suppression, we investigated different soil conditions in which E. coli O157 is able to persist. For this part of Specific Aim 2, soil was collected during the summer of 2013 from a relatively acidic field site on the Ohio Agricultural Research and Development Center in Wooster, OH to establish soil

samples forming individual gradients of the chemical factors of pH, organic matter, and moisture content. Soil samples at all gradient levels were assayed for anti-E. coli O157 effects by inoculating heated or unheated soil with a green fluorescent protein-labelled E. coli O157 strain and following the fate of these bacteria over time as for Specific Aim 1.

We found that:
•The pH gradient was established as fractions of one lime requirement (LR), which is the amount of lime (g CaCO3/ kg soil) required to raise the pH of the soil to a value of 7.0. The resulting levels of pH ranged between 5.15 (0 LR) and 7.5 (2 LR). We found that soil pH had the greatest influence on the survival of E. coli O157 only when the background microorganisms were removed (heat-treated samples). In the presence of the background microbial flora (unheated samples), no difference in E. coli survival was observed between the different levels of pH. There was a significant relationship observed between pH levels and the relative suppression of E. coli O157 introduced into the soil.
•The moisture content gradient was similarly established as fractions of one water holding capacity (WHC), which equals the amount of water retained by soil after the excess water has been drained by gravity. The five WHC ratios resulted in soil moisture levels ranging from 4.1% (1/10 WHC) to 41.1% (1 WHC). Soil moisture content had the greatest influence on the survival of E. coli O157 only when the background microorganisms were removed.
•The organic matter gradient levels assayed were obtained by adding mature compost resulting in soil organic matter levels ranging from 3.5% (0% added) to 5.0% (6% added). We found that changing the organic matter levels of the soil within the range tested had no effect on the survival of E. coli O157:H7 when the microbial background is present or removed by pasteurization.

In order to understand the biological basis for pathogen suppression, differences in microbial community structure associated with E. coli O157 suppressive soils were determined. The original proposed method was to use high-throughput terminal restriction fragment length polymorphism (T-RFLP) analysis of amplified rDNA sequences to profile the community structure; however, with the success of next-generation sequencing technologies, we utilized this technology to sequence the amplified 16S rRNA gene sequences from the total isolated DNA giving a more vigorous analysis of the soil microbial community at a similar cost. Total DNA from the soil samples collected from the field (n=24; 12 plots, 2 collection times) was isolated, a portion of the 16S rRNA gene amplified, amplicons pooled and sequenced using the MiSeq sequencing platform.

**Goals & Outcomes Achieved:**
By completing the project specific aims, we:
•Determined that microorganisms contribute substantially to the suppression of E. coli O157:H7 in the soil regardless of the chemical nature of the soil

•Identified some of the microorganisms present in the soils which can serve as the foundation for future bio control development
•Successfully developed a statistical model of soil suppressiveness to E. coli O157 based on soil chemical characteristics

Producer Education Outcomes
In the original proposal, we had planned to present our model and its utilization to be shared with over 500 Ohio small fruit and vegetable producers at the 2014 annual meeting of the Ohio Produce Growers and Marketers Association. We were unable to meet this goal as all the data had not been collected and analyzed prior to the January meeting. Our results, however, were presented to participants of the 2014 Organic Food and Farming Education and Research (OFFER) Field Day (June 17) which reached 25 producers. In addition, this research was highlighted in the Research in Focus section of the Ohio Ecological Food and Farm Association (OEFFA) 2014 Summer Newsletter which has an estimated readership between 4500- 6000 individuals, primarily Ohio food and farm business operators.

Scientific Dissemination Outcomes
New knowledge garnered from this project was presented to the scientific community through a poster presentation at the 2014 General Meeting of the American Society for Microbiology meeting in May in Boston, MA. In addition two manuscripts for publication in peer-reviewed, high-impact journals are being written for submission by early 2015.

**Beneficiaries:**
This project was primarily foundational basic science in nature, with a long-term impact of developing a biocontrol for foodborne pathogens, which will impact around 300 specialty crop producers and the vegetable-consuming public in Ohio. The smaller immediately applied portion of the project has already been presented to the 25 participants of the OFFER field day. Many of the specialty crop producers in our area prefer to receive new information in a face-to-face and word-of-mouth fashion (many Amish); therefore, dissemination of this information is not an immediate process nor is it easy to enumerate those that have benefited from this project. Over time, this project will be able to reach the approximate 75 vegetable producers in Wayne and surrounding counties.

Primary project beneficiaries of the results of this study were the specialty crop producers in northern Ohio; however, the vegetable-consuming public will be long-term secondary beneficiaries of this project.

**Lessons Learned:**
Recruitment of participating producers on a timely manner was difficult, as many of these individuals do not have electronic means of communication (including phones). We were unable

to recruit 12 separate farms; however, we were still able to sample 12 plots from 10 farms that were all managed separately for our analysis.

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**Project Title: Hop Production to Enhance Economic Opportunities for Farmers and Brewers**

**Project Summary:**
The craft brewing industry in Ohio continues to grow, and with that the need for ingredients. These craft brewers spend over $4 million importing hops from outside of Ohio. Hops, flowers of the hop plant, are a main ingredient in beer manufacturing, providing a bitterness that balances the sweetness of the malt sugars and a refreshing finish. Based on the increased interest in buying locally grown and produced items, we saw this as an excellent opportunity for The Ohio State University to expand specialty crops research to include hop production. We have developed sustainable production practices directly related to Ohio growing conditions. Data collected from our applied field research has allowed us to educate growers about production, pest management practices, and marketing.

The goal of this project was to develop a new Ohio industry for commercial hop production to capture the estimated $4 million in hop related jobs currently sourced out of Ohio. The brewing industry is continuously growing in Ohio with over 172 licensed craft breweries. Historically hops were grown in Ohio. However, they had been pushed out of the state by insect and disease pressure. With better knowledge and tools to manage these problems Ohio was ready to re-claim this high-value crop. This project evaluated the production and marketing of hops by Ohio specialty crop growers. The Ohio State University: The Ohio Agricultural Research and Development Center managed this project.

We had three objectives for this project:

1. Evaluate hop production and Quality
2. Conduct marketing analysis and expand marketing tools
3. Supporting hop growers to produce and market Ohio hops

**Project Approach:**
Objective 1: Evaluate hop production and Quality
*The Ohio State University hop yards:*
Two ¼ acre hop yards were established in the early spring of 2013. One is located at the Ohio Agricultural Research and Development Center (OARDC) (Wooster, OH) and the other is established at the OSU South Centers (Piketon, OH). High trellis systems (17 ft.) were installed

at each site and rhizomes were planted May 8th-9th of 2013. Each hop yard consists of 10 rows of 18 plants for a total of 180 plants per hop yard. There are 10 varieties planted at each site in a complete block design with the following varieties:

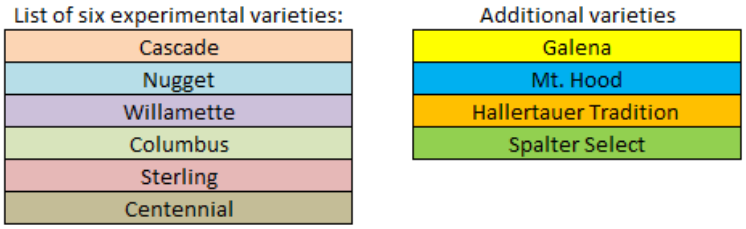


Figure 1: Varieties planted within the hop yards.

The experimental varieties are those which we collected data from. The additional varieties are planted in the border rows to protect our six experimental varieties from pesticide or herbicide drift.

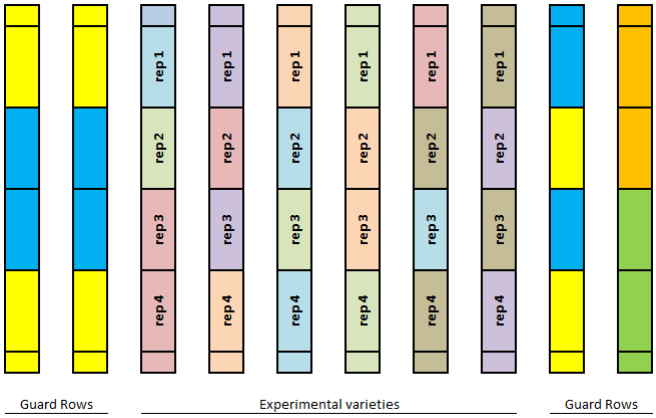


Figure 2: Wooster plots

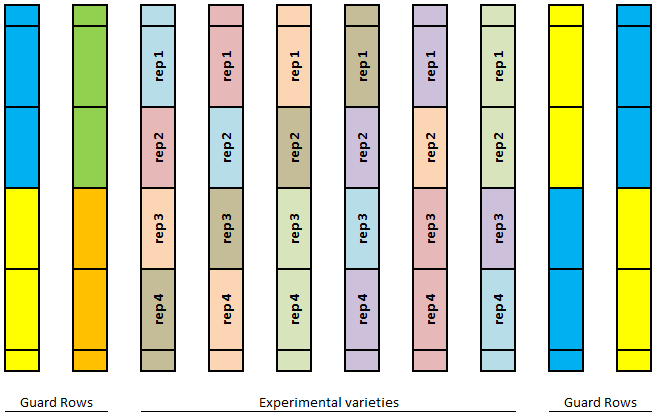

Figure 3: Piketon plots

We have documented every step of trellis construction and rhizome planting with photographs which can be viewed on our website hosted by OSU South Centers: (southcenters.osu.edu/horticulture/other-specialties/hops/hops-photo-gallery).

*Emergence after the severe winter of 2013-14*:
The severe winter that Ohio experienced over 2013-14 did not appear to negatively affect spring emergence of the hops. In Wooster 99% of the plants survived through the winter. Piketon had 100% emergence in their hop yard following the harsh winter.

Figure 4: Hop emergence in Wooster (3/31/2014)

*Data collection*:
We collected the following data from the six experimental varieties:

Pest presence (leaf observations): Leaves were collected from the hop yards weekly for counts of two-spotted spider mite and hop aphid (two major hop pests). Neither was detected prior to harvest in 2013. During the 2014 growing season hop aphids and two-spotted spider mites were detected at low levels which did not cause economic damage the harvested cones.

Natural enemy and pest communities (vacuum samples): Vacuum sampling (Figure 5) of one plant per repetition was conducted biweekly throughout the growing season. The presence of natural enemies and pests within the samples were counted (Figure 6). Potato leaf hopper (PLH) was the most abundant pest. Ohio growers should scout for them weekly to avoid loss especially after any nearby alfalfa (primary host for PLH) is cut. The Wooster hop yard experienced damage due to PLH (hopper-burn) in 2013, but there was no apparent PLH damage in 2014. No economic threshold is known for PLH. The most abundant natural enemy was Araneae (spiders). Growers should consider the impact on spiders when making management decisions, as they prey on various pests such as PLH.

Figure 5: The vacuum sampling method

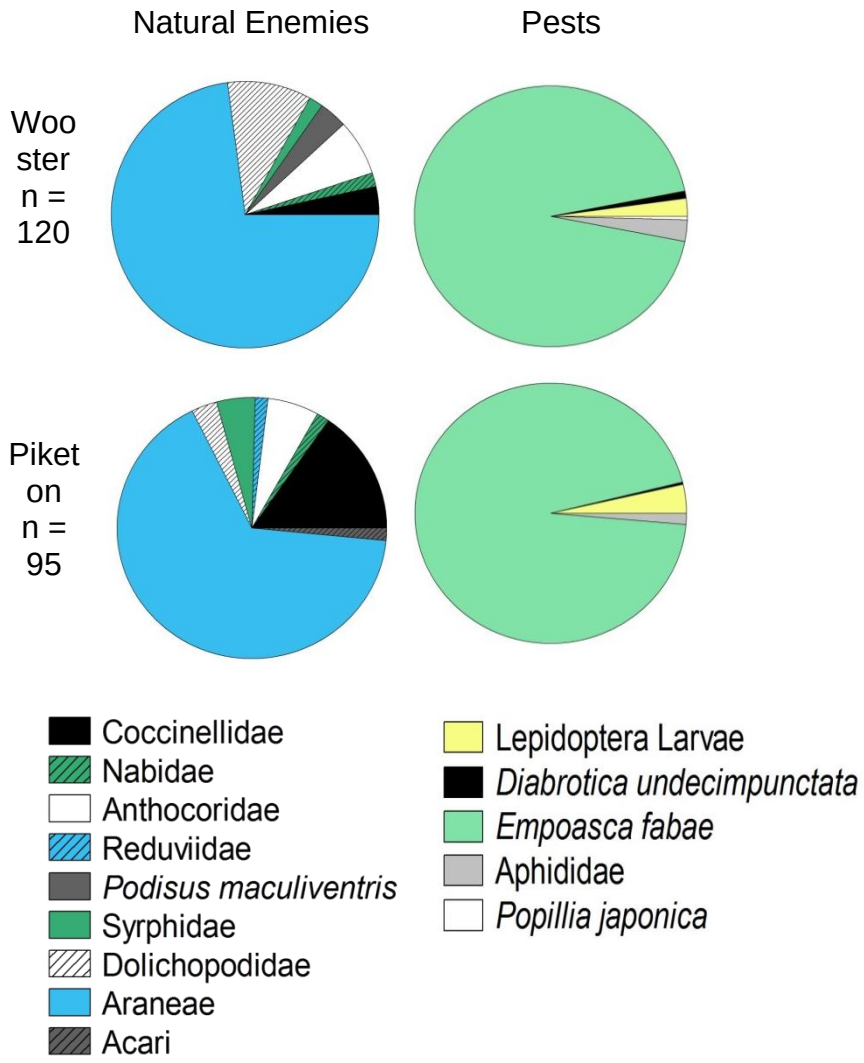


Figure 6: Natural enemies and pests from vacuum samples collected in Wooster and Piketon (2013) summed across the season. Natural enemies detected were: Coccinellidae (lady beetle), Nabidae (damsel bug), Anthocoridae (minute pirate bug), Reduviidae (assassin bug), *Podisus maculiventris* (spined soldier bug), Syrphidae (hover fly), Dolichopodidae (long legged fly), Araneae (spider), and Acari (predatory mite). Pest insects detected were: Lepidoptera Larvae (moth and butterfly caterpillars), *Diabrotica undecimpunctata* (spotted cucumber beetle), *Empoasca fabae* (potato leaf hopper), Aphididae (aphid), and *Popillia japonica* (Japanese beetle)

Disease: In 2013 we did not apply fungicides to either hop yard. Following harvest (2013), members of the Sally Miller Lab (Plant Pathology, OARDC) visited the Wooster hop yard to examine plants for disease. Downy mildew and hop mosaic virus were detected. A report describing these findings has been published as Plant Disease Management Report (8:V172; plantmanagementnetwork.org/pub/trial/PDMR/volume8/abstracts/V172.asp). In 2014 downy mildew was detected in the Wooster hop yard. We sprayed fungicides according to suggestions from the Sally Miller Lab.

Yield data: We collected and analyzed yield data for the six experimental varieties in both hop yards in 2013 and 2014. After the hop cones were harvested they were dried with an oast (hop dryer), weighed, and packaged with a vacuum sealer. Yield data for 2013 and 2014 is included in the tables below:

Table 1: Hop Yields Piketon, Ohio 2013

| Variety | Wet lbs./Plant | Dry lbs./Plant | Wet lbs./Acre | Dry lbs./Acre |
|---|---|---|---|---|
| Cascade | 0.05 B | 0.01 B | 67 B | 13 B |
| Nugget | 0.15 B | 0.04 B | 183 B | 54 B |
| Columbus | 0.92 A | 0.17 A | 1118 A | 216 A |
| **LSD** | **0.45** | **0.09** | **551** | **120** |

*Values with the same letter are not significantly different

Table 2: Hop Yields Wooster, Ohio 2013

| Variety | Wet lbs./Plant | Dry lbs./Plant | Wet lbs./Acre | Dry lbs./Acre |
|---|---|---|---|---|
| Cascade | 0.117 B | 0.0271 B | 142 B | 32.86 B |
| Nugget | 0.1 B | 0.0231 B | 122 B | 28.01 B |
| Williamette | 0.002 B | 0.0005 B | 3.6 B | 0.72 B |
| Columbus | 0.702 A | 0.1655 A | 850 A | 200.25 A |
| Centennial | 0.041 B | 0.0104 B | 50 B | 12.61 B |
| **LSD** | **0.203** | **0.0423** | **246** | **51.19** |

*Values with the same letter are not significantly different

Table 3. Hop yields from Piketon and Wooster Ohio 2013.

| Variety | Wet lbs./Plant | Dry lbs./Plant | Wet lbs./Acre | Dry lbs./Acre |
|---|---|---|---|---|
| Galena Piketon | 0.40 A | 0.1 A | 490 A | 126 A |
| Galena Wooster | 0.33 A | 0.08 A | 401 A | 97 A |
| **LSD** | **0.47** | **0.08** | **572** | **99** |

*Values with the same letter are not significantly different

Table 4: Hop yields from Piketon Ohio 2014.

| Variety | Wet lbs./Plant | Dry lbs./Plant | Wet lbs./Acre | Dry lbs./Acre |
|---|---|---|---|---|
| Nugget | 1.92 A | 0.57 A | 2323 A | 693.62 A |
| Columbus | 1.15 B | 0.36 B | 1396 B | 438.09 B |
| Cascade | 0.78 BC | 0.30 B | 955 BC | 371.8 B |
| Sterling | 0.62 C | 0.17 C | 757 C | 215.55 C |
| Centennial | 0.23 D | 0.08 CD | 283 D | 101.28 CD |
| Williamette | 0.09 D | 0.02 D | 118 D | 24.99 D |
| **LSD** | **0.38** | **0.1** | **468** | **128.87** |

*Values with the same letter are not significantly different.

Table 5: Hop yields from Wooster Ohio 2014.

| Variety | Wet lbs./Plant | Dry lbs./Plant | Wet lbs./Acre | Dry lbs./Acre |
|---|---|---|---|---|
| Columbus | 2.69 A | 1.01 A | 3264 A | 1225 A |
| Nugget | 1.98 B | 0.64 B | 2405 B | 775 B |
| Cascade | 1.29 C | 0.41 C | 1562 C | 507 C |
| Sterling | 0.58 D | 0.18 D | 702 D | 221 D |
| Williamette | 0.46 DE | 0.13 DE | 557 DE | 169 DE |
| Centennial | 0.14E | 0.04 E | 174 E | 53 E |
| **LSD** | **0.39** | **0.13** | **475** | **159** |

*Values with the same letter are not significantly different.

Table 6: Hop yields from Piketon and Wooster Ohio 2014.

| Variety | Wet lbs./Plant | Dry lbs./Plant | Wet lbs./Acre | Dry lbs./Acre |
|---|---|---|---|---|
| Galena Piketon | 0.95 A | 0.29 A | 1160 A | 352 A |
| Galena Wooster | 0.87 A | 0.24 AB | 1056 A | 302 AB |
| Mt. Hood Wooster | 0.34 A | 0.10 AB | 418 A | 121 AB |
| Mt Hood Piketon | 0.13 A | 0.03 B | 157 A | 37 B |
| **LSD** | **0.9216** | **0.2587** | **1115.1** | **313** |

*Values with the same letter are not significantly different.

In 2013 the Columbus variety produced a significantly higher yield than the other five varieties tested at both sites ($p < 0.05$). Being the first year of production this is the expected result. Hop plants typically do not produce much yield within their first year as they direct most of their energy towards producing root systems.

In 2014 Wooster's highest yielding variety was Columbus, while cone production by Nugget was greatest in Piketon. This indicates that the performances of particular varieties may vary across Ohio.

We are expecting peak production starting the third season (2015).

*Chemical analysis*

The hops harvested from the field research trials in 2013 and 2014 were analyzed for their chemical and brewing properties. This analysis was donated by two laboratories: The Portsmouth Brewing Company in cooperation with Shawnee State University Chemistry Department in Portsmouth, OH and The Actual Brewing Company in Columbus, OH.

The traditional lab protocols used for these analyses were developed for fresh leaf (undried) and pelletized hops. The hops we provided to the lab were dried whole leaf hops. Therefore, a new lab protocol was developed for whole leaf hops.

In 2013 seven western grown hop varieties commonly purchased by the Portsmouth Brewing Co. were analyzed along with one variety (Columbus) of Piketon, OH grown hops (Table 7). The % alpha content in the Piketon sample detected by the lab analysis was 6.8% which is low in comparison to the typical amount of 14.5-15.5% for the brewing industry.

In 2014 fresh hop samples were analyzed by the Actual Brewing Company in Columbus, OH for chemical and brewing characteristics. Using spectrophotometry, the % concentration of alpha and beta acids, storage index, original % alpha acid, and % alpha acids lost were performed comparing Piketon grown and western grown hops. Again, the Piketon hops were shown to be low on the % alpha scale. Initially, these lab analyses indicated that the chemical properties of Piketon hops were low in comparison to western grown hops when ICE or international artificial hop standard standards were compared. ICE-3 is an international artificial hop standard that allows breweries to calibrate hop measuring equipment.

In addition to the lab analyses, Master Brewer Fred Lee performed a professional sensory analysis. From this analysis Mr. Lee indicated that the Piketon hops were of exceptional quality, which contradicted the lab analysis. This indicates that the lab protocols need to be improved. The % alpha content is typically measured when the hops are at 8% moisture content. Our lower than normal analysis results may have been due to the Piketon samples having >8% moisture content. The leafy nature of the Piketon hops may have also prevented us from fully extracting the acids.

From these early chemical analysis results we determined that whole leaf hops should be pulverized using a hammermill apparatus to better extract the alpha acids. To aid in future analysis, a protocol using a soil grinder/shredder is now used to pulverize the leafy hop samples prior to testing to achieve a more accurate extraction and analysis.

Table 7: Chemical analysis report (2013). The Piketon sample is highlighted in yellow

| **Variety** | **Typical %Alpha** | **Typical %Beta** | **%Alpha** | **%Beta** |
|---|---|---|---|---|
| Perle | 7.0 - 9.5 | 4.0 - 5.0 | 7.4 | 3.9 |
| Cascade | 4.5 - 7.0 | 4.8 - 7.0 | 4.9 | 7.1 |
| Kent Goldings | 4.0 - 6.0 (US) | 2.0 - 3.0 (US) | 6.3 | 2.6 |
| Tettnang | 4.0 - 5.0 | 3.0 - 4.0 | 4.9 | 3.1 |
| Czech Saaz | 3.0 - 4.5 (US) | 3.0 - 4.5 (US) | 2.4 | 4.6 |
| Perle | 7.0 - 9.5 | 4.0 - 5.0 | 7.3 | 3.9 |
| GR Hallertau | 3.5 - 5.5 (US) | 3.5 - 5.5 (US) | 5.7 | 5.5 |
| Columbus | 14.5 – 16.5 | 4.0 - 5.0 | 6.8 | 2.1 |

Objective 2: Conduct marketing analysis and expand marketing tools

*Brewer survey:*

To determine if there was an interest among Ohio craft brewers in purchasing and using Ohio grown hops, interview surveys of randomly selected Ohio craft brewers were conducted in 2013 and 2014. A brewer's symposium was held as part of Ohio Brew Week in Athens, Ohio in July of 2014 where Ohio craft brewers were asked questions regarding their interest in purchasing and using locally grown hops. Results of these surveys are included below.

Whole leaf vs pelletized hops: 100% of respondents indicated they preferred and/or only could use pelletized hops. They also indicated that they could use dried whole leaf hops and wet whole leaf hops for the growing green brew market. However, each brewer typically produces only one green brew per year.

Aroma vs bittering: According to interviews with brewers and farmers the feasibility of commercial hop production in Ohio will need to focus on aroma hops, or dual purpose hops over bittering hops. This is because:

1. *Price:* Bittering hops are a highly commoditized product with a non-elastic, price point averaging $1-3/lb. Aroma hops maintain product differentiation capabilities that add value and can command a higher, and more elastic, price point. Aroma hops price points can range as high as $25+/lb.
2. *Experimentation:* Brewers expressed an interest in experimenting with any new, unique cultivars that Ohio farms can produce.
3. *Contracts:* Brewers typically lock in multi-year contracts for bittering hops and for certain quantities of aroma hops, they tend to reserve some of their budget for unexpected purchases, enabling them flexibility to experiment and innovate and to purchase local Ohio hops.
4. *Craft Brewer Audience:* Craft brewers continually explore new beer offerings, and seek out new, different or unusual aroma hop varieties. They are more likely to appreciate the unique traits that are derived from these Ohio grown hops.
5. *Product Specifications:* Because aroma hops can be added at different stages during the brewing process, there are opportunities for non-pelletized hops allowing small acreage growers an opportunity to sell whole dried or wet hops.
6. *Growing success:* Field research studies conducted in 2013 and 2014 show that aroma hop varieties are particularly well suited to growing in Ohio and are in high demand by craft brewers. These varieties include Cascade, Centennial, Willamette, Chinook, and Nugget.
7. *Local:* Due to recent high hop prices, hop shortages, and price volatility: brewers surveyed reported they would be interested in making long term relationships with local farmers if the hop quality was as good or better than western grown hops and if growers could provide a consistent supply.

*Ohio Hops Marketing Tools:*
To be successful in agricultural business it is important to have a marketing plan. Several resources have been developed as part of this project to assist hop producers with their direct agricultural marketing plans. Hop and craft brewer specific sections were developed and added to the Ohio MarketMaker network which hosts one of the most extensive collections of searchable food industry-related data in the country. The web based program contains demographic, food consumption, and business data that users can search to buy or sell products. MarketMaker currently links producers and consumers in 19 states plus the District of Columbia. At the beginning of 2014, MarketMaker contained almost 700,000 businesses in categories of AgTourism, Farmers/Ranchers, Fisheries, Farmers Markets, Breweries, Wineries, Eating & Drinking, Wholesalers, Food Retailers, Food Banks, and Other. In 2013, users posted 442 advertisements in the Buy & Sell Forum which were viewed over 36,000 times. Ohio hops growers and craft brewers can set up their free online profile at www.ohiomarketmaker.com.

*Marketing Resource Webinars*
A series of marketing webinars, southcenters.osu.edu/marketing/direct-marketing-webinars, many of particular interest to hops growers, were taught live monthly throughout 2014. These marketing sessions, which help hop growers develop their marketing strategies, were also recorded and are available for viewing. In particular the webinar on hops production and marketing taught on August 28, *Marketing Hops to Ohio Microbreweries*, carmenconnect.osu.edu/hopsmarketing, was taught by Brad Bergefurd. The webinar is available to view at southcenters.osu.edu/marketing/direct-marketing-webinars/2014-webinar-recordings.

Objective 3: Supporting hop growers to produce and market Ohio hops
*Hop Production Feasibility:*
Can Ohio produce local hops for the growing craft brewing industry in Ohio? From these preliminary market and field research results Ohio farms are capable of producing varieties with the quality attributes demanded by the industry. Cascade, one of the most requested hop varieties, produced well in Ohio State field research studies and on farm demonstrations. There are several other varieties that may grow well throughout Ohio and are of interest to Ohio brewers.

According to the Hops Atlas (*Barth, Joh Heinrich, Klinke, Christiane, Schmidt, Claus. The Hop Atlas. Joh Barth & Sohn, Nuremberg, Germany. 1994.*) optimal conditions for growing hops from April to September are as follows:

- A latitude between 35-55 degrees
- Average temperature between 10-19ºC (50-66.2ºF)
- Average precipitation of 64 -569 mm (2.5-22.5 inches)
- Average daylight during these months between 10-19 hours per day

These findings were derived by taking the climate data for top hop growing regions in the world: George, South Africa; Tasmania and Victoria Australia; Rio Negro Argentina;

Oregon and Yakima, US; Hallertau, Germany; Saaz, Czech; and Wye England. In addition, the atlas identified well drained sandy loam as the best soil for growing hops. Ohio has the following climatic and geographic conditions:

- A latitude between 38 and 41degrees
- Average daily high temperature for Columbus from April through September is above 74°F.
- Average precipitation for Columbus from April through September of 594 mm
- Average daylight for Columbus from April through September 12- 14 hours per day

Given these parameters, Ohio has all the required climatic, geographic and agronomic growing requirements to grow hops commercially. From this two year basic feasibility study, it has been found that the right growing conditions for commercial hop production do exist in Ohio.

*Hop acreage report:*
2014 was the first year Ohio was included in the US Hop Acreage Estimate, prepared by Hop Growers of America. Ohio had 30 acres strung for harvest in 2014. We anticipate that this number will continue to increase over the years.
(www.usahops.org/userfiles/image/1403128582_2014%20June%20US%20Hop%20Acreage%20HGA.pdf ).

*Field days*:
We have hosted annual field days at the Piketon and Wooster sites for growers, brewers, and anyone with an interest in Ohio hop production. The first field day took place at the OSU South Centers in Piketon, OH on August 15th, 2013 and there were at least 120 participants. The second 2013 field day was in Wooster at OARDC's Horticultural Research Unit II on September 5th, and there were at least 80 participants. In 2014 the Wooster annual field day was held on July 17th and there were at least 160 participants. The 2014 Piketon workshop was held on August 14th and there were 140 participants.

At these field days we have multiple speakers which cover topics regarding: site preparation, trellis construction, plant and field maintenance, pests and natural enemies, harvesting methods, and marketing. Participation was high during the question and answer periods during all field days.

Figure 7: Participation was high during the 2014 Wooster field day

*Annual Hop Production Workshop:*
We hosted the 1st annual Hop Production workshop in Wooster, OH on February 13th, 2014. With over 350 attendees, this workshop was a huge success! Our speakers (and topics) included: Andy Pax (Beginner's advice from an established grower), Chelsea Smith (Pests and beneficial arthropods), USDA Farm service agency, Fulya Gurel (Diseases and virus control and management in hops), Jason Channels (Ohio Department of Agriculture: Food Safety regulations and requirements for hops processing and sale), Dan Kamburoff (Irrigation design, setup, operation, fertigation and management for hops) and Eric Stockinger (Malting barley research and production opportunities in Ohio).

We are currently in the planning stages for the 2nd annual Hop Production workshop, which will again be held in Wooster for two days (February 5th-6th).

*Publications:*

Two fact sheets are available to the public discussing key pests and natural enemies:

- *ohioline.osu.edu/ent-fact/pdf/0042.pdf*
- *ohioline.osu.edu/ent-fact/pdf/0043.pdf*

*Website and social media:*
A website for this project is hosted by the OSU South Centers (southcenters.osu.edu/horticulture/other-specialties/hops). This website has information regarding our workshops, field days, hop yard tours, Ohio hop production news, and photos.

We have also developed a Facebook page to spread news regarding this project (facebook.com/OhioHops). This Facebook page has 590 "likes" and some of our posts have reached over 1,500 people (Figure 8).

An email list-serv (sc-hops@lists.service.ohio-state.edu) is used to quickly disseminate information to everyone interested in this project. Currently, there are 744 people subscribed to the list. The list-serv has been used to advertise our field days in addition to connecting brewers with growers.


Figure 8: This post to our Ohio Hops Facebook page was seen by 1,655 people.

*VegNet Newsletter:*
The VegNet newsletter provides Ohio growers with weekly updates throughout the growing season. The hops production research team often contributed reports for this newsletter, examples of these reports are shown below.

March 18th 2014:

**CROP REPORTS**

**Hops update (Wooster site): Chelsea Smith, Research Assistant, OSU Department of Entomology**

None of the plants have emerged yet (however this is not a surprise since it has been cold). Once the bines emerge and the tallest bine reaches a height of 2-3 feet we will cut back the first growth and train the second growth.

May 22nd 2014

## Hops Research Update, Wooster

*Chelsea Smith, Research Assistant, OSU Department of Entomology*

The plants are growing fast! We have started training (3 bines per twine). There is no sign of insect damage yet, however, plants have been sprayed for downy mildew and will likely be spraying again soon. This year we will be scouting for aphids, two-spotted spider mite, and potato leaf hopper since they appear to have potential to be the most serious arthropod pests. Japanese beetles, and Lepidoptera larva (caterpillars such as the hop looper, European corn borer, question butterfly, bagworms, and more!) are also of concern.

**Hops bines trained at Wooster.**
Photo by Chelsea Smith

June 12th 2014

## OSU South Centers Update at Piketon

*from Thom Harker & Ryan Slaughter, Research Assistant OSU South Centers*

This week the farm crew has went across the hop yard and removed all leaves and laterals from the bottom 2- 3 feet of the hops bines. This practice is necessary to encourage airflow across the hop yard in order to prevent the formation of downey mildew. Netting over blueberries was also installed this week to prevent bird damage to the berries. Pruning and training has continued in the vineyard to open up canopy for air circulation and sun penetration.

**Grapevine pruning continues**
Photo by Ryan Slaughter

**Hop pruning continues**
Photo by Ryan Slaughter

**Bird Netting installed on blueberry**
Photo by Ryan Slaughter

**Lateral pruning of hops**
Photo by Ryan Slaughter

*Developing relationships:*
We have been meeting with established growers, potential growers, and brewers often. Chelsea Smith has given one-on-one tours of the Wooster hop yard to at least 20 potential growers, throughout 2013 and 2014.

Brad Bergefurd has been developing working relationships beginning in the winter of 2012. He has provided one-on-one individual instruction to 272 individuals interested in hops production.

Brad has developed a partnership with the Ohio University educational program and led and taught a hops symposium at the Athens Brew Week in June of 2013 where over 70 growers and brewers participated.

An important area for developing hops as a new crop for Ohio has been the food safety requirements that need to be applied for Ohio hops processing operations. To educate Ohio growers Bergefurd facilitated the development of a Ohio Hops Food Safety Team which consisted of; Tom Worley, Director, OSU South Centers; Sereana Howard Dresbach, Deputy Director, Regulatory Programs and Lab Services Ohio Department of Agriculture; Terri Gerhardt, Assistant Chief Food Safety Division Ohio Department of Agriculture; and Jason Channels Food Safety Specialist from the Food Safety Division Ohio Department of Agriculture and New Carlisle, Ohio hops farmers Joe Pellegrino and Tom Hoenie. Through the development of this team it has overcome many of the hurdles that ODA and our hops growers had been experiencing in terms of food safety regulations. Now that the ODA understands hop production, processing, and packaging, we are better able to assist and guide our new hop farmers to be compliant with ODA Food Safety regulations.

The Ohio Craft Brewers Association recently hired a new Executive Director, Mary Martineau, who met with us regarding development of the Ohio hops industry. We will be partnering with Mary and the Ohio Craft Brewers Association to continue the Ohio brewer marketing survey phase of this project. Mary is updating the list of Ohio Craft Brewers in Ohio and has volunteered to provide this list to us for the survey.

A relationship has been established with Steve D. Maurer, State Executive Director of the USDA Ohio Farm Service Agency, who has a great vision for Ohio Agriculture to provide the hops and malting barley ingredients to Ohio Craft Brewers. Steve has agreed his agency can support the development of the hops industry by providing federal program benefits to Ohio's farmers and producers' in terms of loans for operating and land purchase, commodity price supports, disaster relief, emergency assistance, conservation and other needed agriculture support efforts.

Relationships are being developed continually with Ohio's 172+ commercial craft breweries that have shown great interest in working with Ohio hops growers as potential suppliers. A few of the Brewers that have been closely involved with the project include; Portsmouth Brewing Company; Cellar Dweller Brewery; Libertatum Arbor Brewery in Chillicothe; JAFB Wooster Brewery, Wooster, Ohio; Jackie O's , Athens, Ohio and Osborn Brewing & Homebrew Supply, Monroe, Ohio.

Chelsea Smith was invited by the Master Brewers Association of America to present the Ohio Hops project progress at their quarterly Midwest District meeting on October 11th 2014. Brewers and staff from many Ohio craft breweries were present such as: Great Lakes Brewery, Fat Heads, Columbus Brewing Company, and Samuel Adams Brewing Company.

Relationships are continually being developed with growers who we are assisting with the formation of an Ohio Hop Growers Guild. The USDA Cooperative Development Center has become a partner to assist with the development and to provide potential funding for the guild's formation. Ohio growers are instrumental to the formation of this guild which currently contains about 40 respective members. The by-laws are currently in the approval process and membership applications have been drafted (Appendix 1). The guild formation paperwork is scheduled to be filed with the State Auditor's office upon approval of the by-laws and election of the Board of Directors.

**Goals and Outcomes Achieved:**
Our goal was to evaluate the production and quality of high value commercially viable hop varieties under Ohio growing conditions to develop a best-practices production protocol for growers.

With the establishment of our two hop yards (Wooster and Piketon) we were able to identify protocols for Ohio growers in addition to comparing six varieties. We observed and evaluated phenology, cold hardiness, diseases and insects, and yield and cone quality.
We determined that our chosen varieties did produce significantly different yields (Tables 1-6). However, growers should not plant a particular variety based entirely on potential yield. It is most important that growers work with their local craft brewers to determine which varieties are desired.

Hop cone quality was examined by determining percentage of alpha acids in addition to sensory analyses (as discussed above in "Project Activities"). The sensory analyses conducted by experienced craft brewers revealed that we were able to produce exceptionally high quality hops.

We provided training on all aspects of hop production through extensive field days and workshops. These events were well received by potential growers. Across the workshops there were over 800 participants, while the development of our website, Facebook page, and email list-serv allowed us to reach an even larger audience. The number of hop growers in Ohio has certainly increased since the launch of this project. At the conclusion of this two year project we feel that we have successfully trained a number of current and potential hop growers. We anticipate that we will continue to operate this program in order to grow and improve the hop production industry in Ohio.

**Beneficiaries:**
A grower who carefully manages their hop yard could see great benefits from the industry this project has supported. Within the first year, growers can expect a yield of 200-1800 pounds per acre depending on the variety with an estimated value of $2,000-$25,200. In the second and subsequent production years yield increases to 500-2200 valued at $7,000-$30,800. Growers could expect to surpass the costs of trellis installation within the first 1-2 years as long as.

Craft brewers are the other main beneficiary of this project. At the time we proposed this project there were 70 licensed craft brewers in Ohio, and after two years, there are now 172. Craft brewers serve as the major consumers of hops, and Ohio breweries currently source an estimated $4 million of hops from out of state farmers. This project has sparked an interest in locally grown hops and increased opportunities for brewers to use locally sourced ingredients. A number of Ohio brewers have expressed an interest in working with local hops and some, such as Actual Brewing Company, have started.

**Lessons Learned:**
We have learned that hops can grow in Ohio successfully. However, they must be managed differently than in the Pacific Northwest due to climatic differences. Since hops are perennial, it can take three years before a maximum yield is produced. Therefore, after just two years of research, we still have more to complete before we fully understand how each variety grows in Ohio's climate and soils. Individuals also need to be well educated before starting their own hop yard. Hops are a high risk crop and it was important that we clarify that to minimize the number of growers who are not prepared to join the hop industry.

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**Project Title: Managing the Emergent Bacterial Disease Threat to Tomato Industry**

**Project Summary:**
As a result of numerous factors including increased number and duration of rain events in Ohio during the tomato growing season, global production and movement of hybrid tomato seeds and insensitivity of bacterial pathogens to copper products, the traditional means of control, bacterial diseases have become increasingly difficult to manage. Bacterial spot, caused by *Xanthomonas gardneri*, has caused millions of dollars in economic damage to Ohio's processing tomato industry since 2010. The goal of this project was to improve integrated management of bacterial spot in tomatoes in Ohio, focusing on the vulnerable tomato seedling production stage, and educate growers on best management practices. During the project, sources of field-expressed resistance to bacterial spot were identified. Multiple products and approaches were tested for

reduction of bacterial spot incidence and severity in tomato seedlings, although none were highly effective. We showed that 1) an integrated approach including sanitized seed, environmental (light, humidity, irrigation) management, sanitation and judicious use of moderately effective bactericides or plant activators is necessary to manage this disease sustainably in tomatoes; and 2) future availability of tomato varieties with improved resistance to bacterial spot will significantly advance prospects for management of this important disease.

In 2010 the bacterial plant pathogen *Xanthomonas gardneri* caused an epidemic of bacterial spot on Ohio's tomato crop. Bacterial spot and another bacterial disease, bacterial canker, continue to cause serious losses in tomato yield and quality. These diseases were a major factor in the 16.8% reduction in processing tomato yield and 34.1% drop in Ohio farm gate value in 2010/11 compared to 2009. Neither disease is controlled by resistant varieties (not available) or registered bactericides (not effective). Tomato producers must learn to manage bacterial diseases if productivity and profits are to be sustained and a thriving processing industry supported. The objectives of this project are to 1) develop a "best management practices" guide for tomato transplant production, 2) develop processing tomato varieties resistant to bacterial diseases, and 3) improve tomato transplant production processes to reduce or eliminate bacterial pathogen populations on plants before they reach the field. The Ohio State University, Ohio Agricultural Research and Development Center, 1680 Madison Ave., Wooster, OH 44691 managed this project.

**Project Approach:**

*Best management practices guides.* Content for an iBook was prepared and the format developed using the software iBooks Author. We worked with tomato seedling producers to produce best practices videos and still shots for the guide. Other photographs were sourced from collections of the authors. Online fact sheets were developed to cover all aspects of diagnosis and management of the major bacterial diseases of tomatoes, particularly bacterial spot, speck and canker.

*Resistance to X. gardneri*. Two hundred and forty processing and fresh market lines as well as 93 wild species relatives were tested for resistance to *X. gardneri* in the field in 2013 and 2014. In order to develop lines with commercial characteristics and resistance to the disease, populations were developed for simultaneous breeding and genetic studies. A potential source of resistance, LA2533, was identified and crossed with a processing tomato line susceptible to the disease (OH2641). Whole genomes of these two lines were sequenced using next-generation sequencing technology. The data obtained for each line were quality checked using an existing data set of 7,700 polymorphisms in the genome.

*Reducing bacterial spot in tomato transplants.* Nine products (Kocide, Cuprofix, Agri-Mycin, Actigard, Cease (*Bacillus subtilis*), Milstop, Kasumin, Aliette and Citrex) alone or in combination were tested to reduce bacterial spot symptoms and *X. gardneri* populations on tomato seedlings planted in low- (288 cell) or high- (338 cell) density seedling trays under

greenhouse conditions typically observed in Ohio during tomato seedling production. In separate experiments conducted at the same time frame, red, blue, amber, green and clear intermittent strobe light radiation was applied to seedlings to determine possible effects on induced resistance to BLS and/or seedling growth. Finally, experiments were conducted in controlled environments (growth chambers) to determine if the timing of exposure to high relative humidity influenced the proliferation of *X. gardneri* on seedlings.

**Goals and Outcomes Achieved:**

*Best management practices guides.* The iBook "Producing Healthy Tomato Transplants" was designed to include chapters on all aspects of tomato seedling production, including but not limited to variety selection, greenhouse structure and location, environmental control in the greenhouse, seed health, sanitation and disease management. Videos and still photography were used to demonstrate seed sanitation, seeding processes, irrigation, disease symptoms, healthy outcomes, and other practices. Due to unforeseen personnel changes and other delays, we were unable to complete the iBook before the project ended. However, we plan to complete the ibook in 2015, in time to introduce it to the Ohio Produce Growers and Marketers Association Congress (60 growers) and regional tomato processors' winter meetings (40 growers per session) in late 2015/early 2016. We will follow upload numbers and conduct anonymous surveys in 2016. Non-federal funds will be used to complete the iBook.

Comprehensive, three-part fact sheets for bacterial spot, speck and canker were developed and posted on Vegetable Disease Facts (u.osu.edu/vegetablediseasefacts/). "The Basics" page, including photos of symptoms, scouting guides and general information about the disease, was also translated into Spanish. "Advanced" pages included detailed information on disease cycles/pathogen biology, and best management practices. "Diagnosticians" pages were designed for laboratory diagnostics guidance.

*Resistance to X. gardneri*. Two accessions from the wild species collection and one line from the fresh market germplasm were identified as resistant under field conditions. Significantly fewer bacteria were found in inoculated leaves of the wild species accession LA2533 than in the leaves of susceptible controls. A genomic region associated with resistance was identified on chromosome 11, known to contain genes controlling resistance for other *Xanthomonas* species causing bacterial spot of tomato. The new population developed from progeny of the cross between LA2533 and OH2641 was selected for specific subsets of chromosome 11. High quality genomic sequences were obtained by next generation sequencing of LA2533 and OH 2641. The accuracy of whole genome sequencing ranged from 98.1% to 99.4%. The sequence data obtained helped us to develop molecular markers to more precisely study the region of the genome associated with resistance.

*Reducing bacterial spot in tomato transplants.* While no treatments affected the number of lesions on leaves, Actigard reduced *X. gardneri* populations compared to the non-treated control regardless of seedling density. Treatment with Cuprofix plus Citrex reduced *X. gardneri* populations at low seedling density, while Kasumin reduced populations at high density. Overall,

*X. gardneri* populations and number of lesions were lower in low-density than in high-density plantings. Red, blue, amber, green and clear intermittent strobe lights had mixed effects on seedling growth, but *X. gardneri* populations on leaves were significantly reduced only by blue light in one of two experiments. Soluble copper on leaf surfaces decreased rapidly with overhead irrigation, however, the use of surfactant increased residual copper compared to treatments without surfactant. Finally, experiments in controlled humidity environments demonstrated that the timing of exposure to high relative humidity influenced the proliferation of *X. gardneri* on seedlings. *X. gardneri* populations were higher on seedlings exposed to high (80%) followed by low (30-40%) relative humidity than on seedlings exposed to low followed by high humidity.

**Beneficiaries:**

Direct beneficiaries of this project are tomato transplant producers who were exposed to information on best practices to manage bacterial spot and other bacterial diseases in tomato transplants at in-person events and online as shown in the table below. Indirect beneficiaries are tomato producers who may expect improvements in the quality of seedlings produced under best management practices guidelines. These growers will also benefit from access to tomato varieties with improved bacterial spot resistance in the future.

| Event | Date | Attendance |
|---|---|---|
| 4th International Symposium on Tomato Diseases and 28th Tomato Disease Workshop, Orlando, FL | June 24-27, 2013 | 125 |
| 29th Tomato Disease Workshop, Windsor, ON, CAN | November 4-6, 2014 | 90 |
| Vegetable Field Night, OSU North Central Agricultural Research Station (NCARS), Fremont, OH | August 6, 2013 | 25 |
| Vegetable Field Night, OSU NCARS, Fremont, OH | July 31, 2014 | 30 |
| Vegetable Disease Facts website launched March 2014 | Analytics for March-October 2014 | 306 visits; 223 unique visitors, 1,791 page views; 7 min:15sec visit duration; 58% bounce rate |

**Lessons Learned:**

Despite setbacks in 2013 resulting from flooding at the field experiment site (Fremont OH), it was possible to obtain data sufficient to identify accessions and lines with elevated resistance to *X. gardneri* through expanded greenhouse screening. Personnel changes also delayed work on the iBook, but information highly relevant to project beneficiaries was included in online fact sheets as a temporary measure. The fact sheets will complement the iBook when published.

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**Additional Information:**

Publications

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**Project Title: Scaling Up the Food Chain**

**Project Summary**:

Working with distributors and growers in two distinct regions of Ohio, our goal was to increase the specialty crop supply available & marketed to retailers and restaurants by providing education support to growers, facilitating relationship building between growers and distributors, and by providing two potentially replicable models.

A 2011 OSU study of specialty crop production and local markets identified distribution as the "missing link" in scaling up this segment of the industry. Researchers found that retailers desire to purchase locally-grown food but cannot manage buying from multiple small suppliers and concluded that: "By working with distributors, small and medium farmers can find market access points into the retail sector." Distributors, recognizing the demand for local product and the benefit it provides by lowering transportation costs, were enthusiastic. The report concluded: "Creating relationships of trust between distributors and producers is key to expanding market opportunities for Ohio-grown fruits and vegetables."

Starting with this conclusion, this project set out to (1) establish two grower-distributor networks in Central Ohio and Northeast Ohio to move local specialty crops into retail markets. Educational and technical assistance supports were provided to help specialty crop growers (2) expand production volume, and (3) develop new skills for managing their farm businesses. Together, these were intended to increase specialty crop production, increase industry profitability, and provide two network distribution models that could be adopted elsewhere in Ohio. Cuyahoga Valley Countryside Conservancy and Ohio Ecological Food and Farm Association managed this project together.

**Project Approach:**

*Objective 1: Specialty crop growers gained new skills and knowledge to improve product quality and consistency, increase yields, and expand production to meet distributor needs.*

To that end the following activities were conducted: Sixty-six workshops were held on topics related to producing consistent high quality products and increasing scale. One hundred thirty six direct technical assistance interactions about specialty crop production occurred over the two year grant. Eighteen on farm experiences were held related to expanded scales of production and working with distributors. Most of these workshops were held at the OEFFA Conferences.

<u>A sampling of the workshops:</u>

**"Wholesale Marketing for Fresh Produce Growers,"** presented by Attina Diffley, and organic farmer, consultant, and co-editor of Wholesale Success: A Farmer's Guide to Food Safety, Post-Harvest Handling, Packing and Selling Produce. Topics covered grading, pricing, and packaging; brand name marketing; establishing contracts; shipping options; sequential cropping, and more.

"**Growing Great Organic Potatoes**," presented by Jake and Dawn Tretheway, organic farmers. Topics covered pre-planting preparations, variety selection, planting, weed and pest control, fertility, and harvest.

"**Organic Transplant Production**," presented by Stewardship Award winners and organic farmers Doug Siebert and Leslie Garcia. Topic covered selecting trays and soil mix, seeding, watering, lighting, potting, insect and soil chemistry problems in the greenhouse.

"**Growing Specialty Greens for Market**," presented by Matt Herbruck, organic farmer. Topics covered planting coordination and variety selection, which can produce a continuous supply of greens nearly year round. Also covered were his methods for direct seeding, transplanting, cultivation, and harvesting.

"**Plasticulture Strawberry Production to Extend Your Market**," presented by Brad Bergefurd, Ohio State University Extension, and farmer. Topics covered technics that have been researched and demonstrated to be successful in Ohio, resulting in harvesting strawberries two to three weeks earlier.

"**Microclimate Management in High Value Vegetable Production**," presented by Matt Kleinhenz and his research team, Ohio State University. Topics covered mulches, row covers, low-, mid- and high tunnels for management, discussing pros and cons, most effective use, and why they work.

"**Saving Labor on a Market Farm**," presented by Chris Blanchard, farmer and consultant. Topics covered efficient systems for seeding crops in the field and greenhouse, transplanting sets, pruning, caring for greenhouse crops, weeding, harvesting, post-harvest handling, materials handling, and recordkeeping.

A sampling of on farm learning experiences:

**Organic Farm Production and Business Management**, Birdsong Farm, Portage County, Ohio. Greens, herbs, root crops. Birdsong Farm is a family-owned certified organic farm. Owner Matt Herbruck has been in the farming business for 18 years.

**Cold Season Vegetable Production**, Turner Farm, Hamilton County, Ohio. Fall and winter lettuce, arugula, carrots, parsnips, kale, broccoli, and cauliflower. Turner Farm is 160 acres with approximately six acres of certified organic vegetables, herbs and flowers, with production in high tunnels, cold frames, and under row cover year round.

**Organic Fruit and Vegetable CSA** , Fulton Farms, Miami County, Ohio. Diversified operation that serves more than 400 families in the Dayton area through its CSA program. Fulton Farms has 30 acres of certified organic fields, nine high tunnels, a packing area, nursery greenhouse, and compost operation.

**Diversified Produce, Livestock and Farm Market**, Sirna's Farm and Market, Geauga County, Ohio. Hydroponic produce grown in high tunnels and raised beds. Established in 1997, Sirna's Farm has found ways to produce higher yields without completely relying on the volatile Northeastern Ohio weather, as well as the use of chemicals.

Profitable High Tunnel Management, May 6, 2014. Presented by Adam Montri, owner/operator of Ten Hens Farm and Michigan State University Department of Horticulture Hoop-house Outreach Specialist. Topics covered identifying cost of production; fertility, disease and pest management; profitable crops and cultivars; successful rotations; pricing of product; and marketing strategies.

Scale Appropriate Farm Machinery for Specialty Crop Production, November 6, 2014. Presented by Jean-Paul Cortens of Roxbury Farm, a 300 community supported agriculture farm that serves approximately 1200 families. The webinar covered the various pieces of equipment used at Roxbury Farm to produce vegetables, and discussed the best equipment to use for tillage, weed control, mulching, planting, seeding, harvesting, and haymaking. He explored how different pieces of equipment can be integrated to maximize their effectiveness.

Organic Inputs: Options and Opportunities for Improving Crop Health and Productivity, November 20, 2014. Presented by Brian B. McSpadden Gardener, Ph.D. Director, Organic Food, Farming, Education & Research Program, Department of Plant Pathology at The Ohio State University – OARDC. This webinar reviewed key concepts and principles involved in choosing inputs acceptable under the National Organic Program. Information discussed will help growers make sound and profitable choices for their farming operations.

January 14 Farm Record & Bookkeeping, Mary Ann Burger, CPA, Cuyahoga Falls, OH
February 11 Financing Your Farm Business, Rob Ziemkiewicz
March 4 Cultivating a Farmer-Chef Relationship, Ben Bebenroth, chef and farmerat Spice Kitchen and Bar, Cleveland
April 22 Farmers & Beekeepers - How Can We Keep Bees Alive?, Peggy Garnes.
August 5 Planning For Growth, Chris Blanchard, Flying Rutabaga Works and Rock Spring Farm
August 20 How to Be a Better Boss on the Market Farm, Chris Blanchard,Flying Rutabaga Works and Rock Spring Farm
August 27 Systems for Accountability and Efficiency on the Market Farm, Chris Blanchard, Flying Rutabaga Works and Rock Spring Farm
September 15 Equipment to Scale Up Your Fruit and Vegetable Operation, Johnny Parker, Edible Earth Farm

**Scaling Up the Food Chain -- November 2-5, 2013, Wooster, Ohio**

Session 1, "Expanding Produce Production and Meeting Large-Scale Buyer Demands," focused on production techniques that work on larger-scale sustainable farms. Presenter: Linda Halley, Gardens of Eagan.

- Growing transplants on a larger, more efficient scale
- Planting from transplants and direct seeding: techniques and equipment from the perspective of a larger grower
- Weed control on a large scale
- Meeting demands of distributors, institutions, stores, restaurants and cooperatives
- Picking, washing, packing, cooling and storage: getting bigger, more efficient and keeping food fresh and safe
- Delivery
- Resources for expansion

An organic produce grower since 1989, Linda Halle spent 15 years as the co-owner of Harmony Valley Farms in Wisconsin, a highly successful certified organic farm with a diverse marketing strategy that includes a CSA, farmers' markets, and wholesale sales. Today she manages 100

acres of transitional organic production at Gardens of Eagan in Minnesota, another thriving farm with a diversified marketing strategy.

Meet the buyer networking, an evening during the intensive series where growers could interact with interested buyers including Cuyahoga Valley Environmental Education Center, DNO Produce, and several small grocers.

Four webinars on scaling up with nationally recognized speakers were conducted. A two- day intensive session on scaling up production occurred, including time for building a network and community of advanced growers, and included seven workshop topics.

*Objective 2: Specialty crop growers gained new business skills to take advantage of increased marketing opportunities.*
Activities included: Eighteen webinars on business, marketing and management topics; ninety-seven instances of direct technical assistance germane to market connections; and a two-day intensive series including six workshop topics.

Session 2, "Growing and Managing Your Farm Business," concentrated on business practices for thoughtful and sustainable expansion. Presenter: Chris Blanchard, Flying Rutabaga Works.

- Equipment for scaling up
- Infrastructure for scaling up
- Employees
- Planning the growth of your farm and effectively, prioritizing equipment, infrastructure, and employee needs
- Financing options for expansion
- Bookkeeping and recordkeeping processes
- Balance sheets and income statements; effectively interpreting financial reports

Since, 1999, Chris has owned and operated Rock Spring Farm in Iowa, a 15 acre vegetable and herb farm that supplies a 200 member CSA, food stores, and a farmers' market. Through his consulting business, Flying Rutabaga Works, Chris offers education about and assistance with systems development and documentation, food safety and GAPs compliance, business planning and management, post-harvest handling, and more.

*Objective 3: Specialty crop growers in Ohio received GAP training.*
Online and in-person GAP trainings were conducted. Additionally, an online training regarding FSMA impacts to small growers was conducted. Two other additional GAP trainings were scheduled but canceled due to lack of registration.

*Objective 4: Specialty crop growers and distributors worked together (and independently) to build the supply chain of local identity-preserved specialty crops.*
Talks with DNO led to the understanding that DNO wanted to create their own branded line of organic products, and were looking for suppliers. Some suppliers were not comfortable giving up their brand identity. After much discussion a group of growers came together to form an organic produce farmer network, that will be delivering 'market bags' for household consumers. This is seen as a step in the right direction to be able to scale up and grow into a wholesale market. Meetings were held with a designer to finalize promotional concept and developed text for the first piece. Farmers and a photographer's schedules were coordinated in order to secure images

for the promotional piece. A market ready training was held for growers in central Ohio. Discussions with growers in Northeast Ohio yielded some interest in pursuing relationships with Premier Produce. Premier Produce, however, after a short time decided that they did not want to pursue the project. Repeated attempts to connect with other wholesale distributors were met with disinterest. Other avenues were attempted- working directly with chefs, and with Summa of the Western Reserve, to see if we could help connect them with suppliers. Due to time constraints as well as budgetary concerns these conversations still remain at the conversation stage. A meet the buyer session was held as part of the four-day intensive series held in early November 2013.

*Objective 5: Distributors improved understanding of how to work with small and mid-scale farms.*
Given the lack of interest in participation in the project from the buyers side, this piece did not progress.

**Goals and Outcomes Achieved:**
*Objective 1: Specialty crop growers will gain new skills and knowledge needed to improve product quality and consistency, increase yields, and expand production to meet distributor demands.*
2797 farmers participated in workshops through this grant, out of a projected 900.
136 farmers were provided with direct technical assistance out of a projected 440.
2051 people participated in on-farm experiences, out of a projected 300.
437 people participated in the webinars out of a projected 300.
38 farms were served through a two-day intensive series out of a projected 40.

*Objective 2: Specialty crop growers gained new business skills to take advantage of increased marketing opportunities.*
305 farmers were served through online business webinars, out of 1050 projected.
97 growers were provided with direct technical assistance out of 100 projected.
28 growers participated in an intensive business planning workshops during a two-day series.

*Objective 3: Specialty crop growers in Ohio received GAP training.*
293 Growers underwent GAP and other food safety trainings, out of a projected 270 growers.

**Post-Harvest Handling, Food Safety, and GAP: Making It Work on a Real Farm**, February 15, 2013, Granville, Ohio

This all day workshop, with 80 people in attendance, was presented by farmer and food safety expert Chris Blanchard of Rock Spring Farm in Iowa. Chris taught participants how to establish or improve food safety practices. He reviewed post-harvest handling practices and shared methods for meeting Good Agricultural Practices (GAP) documentation and record-keeping requirements in a way that flows with the work on the farm, rather than existing as a separate set of tasks and requirements.

Chris also conducted the webinar on Food Safety, with basic steps to improve food safety practices on the farm.
Food Safety Regulations Webinar: Impacts to Small Growers and Processors, September 23, 2013. Ariane Lotti, Assistant Policy Director for the National Sustainable Agriculture Coalition,

presented an overview of the proposed Food and Drug Administration food safety regulations: who is affected, and how the rules could impact small farmers. The webinar was attended by more than 80 people.

Great River Farms had:

- Eight participating farms
- 11 acres in production (specific to this marketing collaboration)
- $113,895 in total sales (specific to this marketing collaboration)
    - This figure was determined by sales only; not by pounds.
- This marketing collaboration represented 3-33% of each farm's sales (for an average of 14%)

Great River Farms, which is currently transitioning to Great River Organics, deliberately restricted the number of farms that participated in its inaugural year. This ensured that each farm would receive a meaningful income from this marketing effort (rather than having many farms who only were able to market a token amount through this outlet), as well as work out any kinks or structural issues.

The original plan was to measure the progress and success of the project, at the beginning, middle, and end of the project, but the program took so long to get off of the ground, we only have end statistics as opposed to beginning, middle and end. Ending statistics are outlined below:

- Between April and September the approximate value of Ohio sourced specialty crops was $700,000. USD
- This project provided service for approximately fifty (50) farms: ten (10) fruit, thirty-five (35) vegetable, eight (8) mixed.
- The majority of farms had less than ten (10) acres in production; five (5) farms had over fifty (50) acres in production.
- Five (5) vegetable farms sent 100% of harvest through Ohio First; twenty-five (25) farms about 50%. Ohio First is a branding program to identify Ohio grown specialty crops.

Additionally, Yellow Bird Distribution highlighted their successes:

- Distribution services provided for 28 central Ohio farmers, representing between 5% & 50% of harvest.
- Farms ranged in size from 1 – 25 acres in specialty crop production.
- Value of purchased crops was approximately $125,000.

2015 Yellow Bird Distribution projections:

- 50% increase in number of farm participants
- 20% of 2014 farms expect 100% of harvest to be distributed through Yellow Bird
- 80% of 2014 farms will increase production acreage

- 100% - 200% growth in value of purchased crops

*Objective 4: Specialty crop growers and distributors worked together (and independently) to build the supply chain of local identity-preserved specialty crops.*
28 growers participated in an initial Market Ready training, out of a projected 20 in Central Ohio.

No growers are supplying DNO through these efforts. Instead, 8 growers are pulling together a branded organic suppliers network called Great River Organics.
Branding for the Great River Organics is underway, instead of completed as projected.
Market ready trainings were also scheduled but cancelled in NE Ohio due to lack of registration.
No growers are working with Premier Produce out of a projected 15.
A Train-the Trainer session was not able to be conducted due to challenging schedules, staff changes, and the person conducting the training's own position change.

*Objective 5: Distributors improved understanding of how to work with small and mid-scale farms.*
We did not hold training or farm visits for distributors, due to lack of engagement.

**Beneficiaries**:
6218 connections were made during the span of this project. Beneficiaries include the farmers who participated in the workshops, farm tours, webinars and intensive series, to the consumers who were able to increase their access to local food through projects such as Great River Organics.

**Lessons Learned:**
Our experience in Columbus with DNO Produce took a different direction than anticipated, but in the end, a workable situation for both farmer and distributor has been established. Going into this project we knew DNO Produce had opportunities to sell certified organic produce to retail establishments.

Fairly early on in the start of our project work, DNO had decided to create its own certified organic brand. Farmers that we spoke with who had the potential to scale up and sell to DNO did not find the price point they wanted to consider this (as a) sole relationship. However, wholesale distributors, including DNO Produce and Sanfillipo Produce, are critical pieces of the farmer's puzzle to sell excess produce as he/she scales up production. As these growers develop a plan to move away from more labor intensive direct marketing work, such as farmers' markets, wholesale selling will remain an important (and possibly more central) strategy.

1. There is timidity with growers to scale up and integrate (more) wholesale opportunities into their farm business. Partly this is a knowledge gap, which this project did a great job to fill in (and our attendance #s reflect the desire for this information). This grant allowed us to bring in successful farmers who have made this transition to share their knowledge and lessons learned. The other is having farmer leadership, and/or an established structure to tap into.

2. Farmers that we worked with said they were less concerned about retaining individual farm identity, and sometimes--because they no longer had control of their product--were concerned about their identity being carried forward once they sold to a wholesale distributor. Efforts, such as the Great River Farms/Great River Organics, keep control in the farmers' hands, but by collaborating on a production and aggregation strategy, are better able to tap into the wholesale market.

3. Related to #1 & #2, produce farmers that have started their businesses through direct marketing, need a vehicle to mitigate (to a certain extent) risk in order to consider and feel comfortable about expanding or transitioning to wholesale distribution.

4. A critical component identified is the limited pool of experienced and competent labor who can come in at the management level to help farms meet the demands of increased production.

5. Desirability of joining hub/cooperative projects increases with the level of externalized services these projects provide. Obviously, collaborative marketing is primary, but other services like accounting & business management, HR services, food safety planning, regulatory compliance, etc., can provide the economy of scale necessary to entice midlevel producers.

6. Certain seasonal window of opportunity directly correlates to levels of participation, and the opposite. Corralling producers/presenters and attendees for in-season educational events is challenging, farm tours notwithstanding. Even with the marginal push-back from the November intensive, I think we hit the mark on the seasonal cycle.

In Northeast Ohio, we had anticipated some timidity with growers in developing the relationships with distributors. However, what we found was that the biggest barrier was getting the distributors on board. Grocery stores and even chefs were much more engaged in the conversation and willing to get involved with local growers than were distributors. Our original partner, Premier Produce, was enthusiastic at the start, but when it came time to begin enacting plans their engagement evaporated.

In conversations with several other distributors over the two year period, even when heads of the organization were excited about the opportunities, the on-the-ground buyers were disinterested.

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**Project Title: Food Safety Education**

**Project Summary:**
This project continued the effort of the 2011 project, which was to provide produce growers, handlers, and other industry professionals with instruction (at no charge) that could preclude food safety lapses. For this year, we increased the quantity of food safety education with an increase and principal focus of the formal educational programs. We learned from the 2011 project that while we raised the level of awareness of core food safety concepts and related certification, we didn't adequately address the needs of medium and large sized growers who are already required to obtain certification from other 3rd-party certification programs. This year's effort sought to address that deficiency.

The project fulfilled a number of priorities, including:

- Supporting efforts to reduce or mitigate risk for specialty crop producers.
- Implemented programs or projects that provide outreach and education on the importance of the industry with regards to Ohio's economy, food safety or the nutrition and health benefits of specialty crops.
- Enhanced the understanding of food safety and related areas.
- Leveraged investment of previously awarded grants to take the initiative to the next level.

**Project Approach:**
Food safety scares have become an all too common reality. Lapses in safety practices have resulted in food-borne illnesses, creating significant human suffering and economic hardship from consumer backlash for growers who have diligently followed appropriate food safety procedures. This project was an effort to bring greater awareness and technical training to producers and handlers in Ohio.

1. Ten Food Safety sessions were offered at 2013 OPGMA Congress, Dates: January 21-22, 2013. Titles, speakers, attendance, session and average speaker ratings are provided.
    a. Food Safety Basics.
    b. Ohio Product Marketing Agreement: Auditor Comments & Grower Experiences.
    c. Food Safety Issues & Deficiencies on Farms.
    d. Environmental Testing & Microbiological Detection Techniques.
    e. Dealing with Salmonella & E. Coli Contaminated Soil.
    f. Understanding and Managing Listeria Survival in Ag Environs.
    g. Produce Food Safety Research: What It Means for Me Part 1.
    h. Produce Food Safety Research: What It Means for Me Part 2.
    i. Food Safety Issues: Ask the Experts.
    j. FDA-FSMA Update.
2. A session was offered at the 2013 OPGMA Summer Tour & Field Day Food Safety.
3. Food safety articles published in the OPGMA Newsletter (published four times a year).
    a. Ohio Produce Marketing Agreement – Let's Talk Certification.
    b. Certification: Quality Auditors & Inspectors Make a World of Difference.
    c. OPMGA: It's Time to Schedule Your Inspection.
    d. OPMA Inspection Process: Your Questions Answered.

4. Surveys were conducted of program participants to measure their understanding before and after the programs. The results were used to enhance the educational strategies.
5. Expanded marketing was used to recruit more farmers to participate in food safety programs. There was an extra effort made for communities that are less connected to the industry's formal communications networks (e.g., Amish and Mennonite).

**Goals and Outcomes Achieved:**

Goal #1: To increase grower attendance at food safety sessions at the OPGMA Congress and the OPGMA Summer Tour & Field

- Nearly 400 small – large producers participated in the numerous programs offered. Additionally, countless more were made aware of the availability and necessity of food safety training through our marketing and other outreach initiatives.

Goal #2: Measure attendee evaluation of the quality of the sessions (educational content) at the two programs.

Based on our feedback from the 2011 program, we redesigned some of our core programs to increase the comprehension of the important principals of good food handling practices. Across the board, our surveys showed an increase in understanding of the issues and the necessary skills to improve handling practices. The goal was to have a score of between 6.0 and 7.0 for both speakers and sessions. Based on the proposal, scores for both speakers and sessions are based on a 7 point Likert scale, with scores 5.5 to 6.0 being considered excellent and those above 6.0 being considered outstanding. Scores from the previous year's (2011) OPGMA Congress program were 6.1 for speakers and 5.5 for sessions. Please see the 2015 evaluations results in the chart below.

2013 OPGMA Congress attendee survey responses to Food Safety session and speaker evaluations.

| **Session Title** | **Speaker(s)** | **Speaker Score[z]** | **Session Score[y]** |
|---|---|---|---|
| Food Safety Basics | Ashley Kulhanek | 6.1 | 5.6 |
| OPMA Status Update, Auditor Comments | Karl Kolb, PhD | 6.4 | 6.1 |
| Most Common Food Safety Issues & Deficiencies on Farms | John Eade; Karl Kolb, PhD; Andy Moreno PhD | 6.0 | 5.6 |
| Environmental Testing & Microbiology Detection Techniques | Karl Kolb, PhD; Andy Moreno PhD | 6.1 | 5.7 |
| Dealing with Salmonella & E. Coli Contaminated Soil | Trevor Suslow, PhD | 6.6 | 6.2 |

| | | | |
|---|---|---|---|
| Understanding and Managing Listeria Survival in Ag Environs | Trevor Suslow, PhD | 6.5 | 5.7 |
| Produce Food Safety Research: What It Means for Me Part 1 | Lawrence Goodridge, PhD; Michelle Danyluk, PhD; Jeff LeJeune, PhD | 6.0 | 4.7 |
| Produce Food Safety Research: What it Means for Me Part 2 | Lawrence Goodridge, PhD; Michelle Danyluk, PhD; Jeff LeJeune, PhD | 6.0 | 5.3 |
| Food Safety Issues: Ask the Experts | Lawrence Goodridge, PhD; Michelle Danyluk, PhD; Jeff LeJeune, PhD; Karl Kolb, PhD; Trevor Suslow, PhD | 6.5 | 5.5 |
| **Average Scores** | | **6.2** | **5.6** |

[z] Average Speaker Scores are averaged across all the speakers for a given session in response to two questions: "Speaker exhibited thorough knowledge of subject" & "Speaker effectively communicated information."

[Y] Session Score for each session is the average attendee response to the question: "This session was relevant to my current position." The relatively low avg session score (5.6) compared to the avg speaker score (6.2) might be explained in the following way. A portion of the attendees who chose to attend the food safety sessions found the information supplied, while outstanding (as indicated by the speaker score), found during the course of the session that it wasn't a relevant to their current needs as originally anticipated.

Because the majority of growers attending OPGMA Congresses are small to intermediate growers who do not sell produce on an interstate basis, we felt that it might be more informative to ask the growers if they plan to implement what they learned at the program and to give examples. Approximately 84 percent of the attendees indicated that they planned to implement some aspect of what they learned. Specific examples given:

- Product and environmental testing. More rigorous GAP program. Develop a plan for recalls. Change traceability process/system. Implement cleaning/sanitizing crew and processes
- Incorporate the use of chlorine and other sanitizers. Developing documentation. Plan to implement ATP testing on a regular basis.
- Still studying and evaluating.
- Started food safety in 2001, first Primus audit in 2003
- Better record keeping
- Create HACCP plan. Will implement food safety practices
- Upgraded water supply to municipal water
- Don't pick produce off the ground, wear gloves mark boxes where fruit was picked
- The way I grow and wash vegetables
- Upgrade to municipal water supply
- Developing a HACCP

- HACCP plans
- Have done GAPs since 2001 on our own at various other training areas
- Begin developing plans. Initiated facility improvements. Downsized operations.
- Better record keeping, packing differently, animal barriers

Goal

We met the goal of providing a more advanced lineup of sessions to elevate the knowledge baseline of attendees in providing five cutting-edge sessions and an "Ask the Experts" type session. We made attempts to include Dr. Samir Assar of the FDA as a speaker during the program (he has spoken at a previous program) but were unsuccessful – presumably because FSMA was (and is) still a work in progress.

Target

We met the goal of having 75 percent of attendee respondents indicating that they planned to implement some aspect of what they leaned during the food safety portion of the program. Almost 84 percent responded in the affirmative.

Benchmark

Because the nature and scope of the food safety education offered during the 2013 OPGMA Congress program differs for the 2012 program, we didn't try to break responses into the same Core Food Safety Concepts, How to Implement GAPs, and OPMA & Certification categories of the 2012 program. So aggregating across the 2012 categories, attendees felt their knowledge level for material to be presented during a given session was 2.6 (out of 5. 5 = very knowledgeable, 1 = novice) before the session and 3.8 post. For the 2013 program, the numbers were: Pre – 3.1; Post – 4.0.

**Beneficiaries:**

While our program was focused on producers and handlers, the general public is the ultimate beneficiary of the project. It is difficult to provide a quantification of the positives to the beneficiaries for growers implementing knowledge gained during the program as what is gained is the potential avoidance of significant economic, legal, and health losses as a result of lapses in food safety protocol. FDA states in the proposed produce safety rule, that between the years of 1996 and 2010, approximately 131 produce-related reported outbreaks associated with 20 different fresh produce commodities occurred, resulting in 14,132 illnesses, 1360 hospitalizations, and 27 deaths. These numbers are significant and have shaken consumer confidence in one of the safest produce supplies in the world. In addition, they have resulted in collateral economic hardship for many produce growers, including some in Ohio.

Consumers need to have more confidence that the food they consume (raw or processed) has been handled in the safest manner. Food sellers (markets, grocery stores, etc.) also benefitted because they can offer a better product to their customers and therefore increase their sales. Finally, food safety experts (researchers and instructors) advanced their understanding of the needs of consumers, producers, and handlers.

**Lessons Learned:**
The lessons learned are really ongoing. While producers and handlers were generally more aware of the surrounding issues of food safety, it will take many years to impact and change cultural practices and long-standing behaviors. We believed there would be greater acceptance and earlier adoption of good handling practices. Furthermore, we need to have more direct contact with the handlers and field staff instead of just the ownership and management of the farms. In short, food safety education is needed every day and must be ongoing.

Also, very few producers and handlers were aware of the FDA-FSMA therefore this program brought more understanding of the related goals and guidelines under consideration at the time.

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**Project Title: Retail Marketing Program**

**Project Summary:**
For this project, the Ohio Grocers Foundation (OGF) partnered with the Ohio Produce Growers and Marketers (OPGMA), Ohio Ecological Food and Farm Association (OEFFA) and the Ohio Department of Agriculture (ODA) to increase awareness and sales of Ohio's specialty crops and products made from specialty crops. This project enhanced the competitiveness of Ohio's specialty crops through advertisements, in-store signage, in-store product tastings and a statewide media campaign. The message carried the same theme to educate and encourage consumers to purchase Ohio specialty crops and products made with specialty crops. This project is timely because consumers now more than ever want to purchase local foods and they are interested in meeting the person who is growing their food. Consumers' interest in purchasing local produce continues to increase and they may not be familiar with all the different types of specialty crops available in Ohio.

Ohio's specialty crop industry plays an important role in the state's economy. Ohio ranks in the top 10 nationally for production of tomatoes, cucumbers, sweet corn, apples and strawberries. Consumers' interest in buying local products continues to increase. The average Ohio consumer visits the grocery store 2.3 times per week. However, many of these consumers are not familiar with the different types of specialty crops that are available in Ohio nor the time of year they are available. In-store signage and product tastings educated consumers at the retail level about the availability of Ohio's specialty crops.

**Project Approach:**
The first task of the project was for all the partners to survey their memberships. OGF surveyed their members to explain the project and find out what type of promotional pieces would work best for them. OPGMA and OEFFA surveyed their members to determine who sells to retailers, their buyer contacts, types of promotional materials needed, and their ability to track sales. The next task was to develop the RFP for a PR/Communications firm to develop the materials and

media campaign. Two companies (The Orchard Group and AR Marketing) submitted proposals to manage the communications and PR for the project. The partners awarded the contract to AR Marketing, as they had previous experience working with grocery stores and marketing campaigns. The contract was for $39,740 and that included branding of all materials, artwork, media creation (website, Facebook page, Twitter) and fulfillment (shipping of all materials to stores). AR Marketing developed the "Oh So Fresh" theme for the project.

The promotional tool kit that was mailed to the participating retailers included the following: Promotional window sign, department poster, ceiling danglers, shelf tags, employee buttons, Oh So Fresh product decals and bag stuffers. The kit was sent to all participants (94 grocery stores) and the product tastings/demos were scheduled.

AR Marketing developed a social media campaign for Twitter and Facebook. AR Marketing (the contracted Communications firm) set up Social Media sites to promote the program. During the marketing campaign, AR Marketing updated the Facebook(OH So Fresh) page to highlight farmers, grocers, specialty crops and growers and also posted recipes. Some recipes included: Pickled Peppers, Pumpkin Soup, BLT Salad, Apple Chips and Roasted Cauliflower. AR Marketing also used Twitter to provide updates. One grocery chain sent out an email blast to their customer list to promote the program. The Ohio Grocers Foundation promoted the program to retailers through their weekly "checkouts" email list to more than 1,000 of their members. The Weekly Checkouts were on 6/26/13 and 7/18/13. (Several other Weekly Checkout messages were sent prior to actually starting the campaign to announce the program to OGA members and encourage them to participate.) OEFFA distributed news release in July 2013 to their 2,800 membership list to promote and provide information about the OH So Fresh program. Since the marketing firm managed the social media and news releases for the Oh SoFresh Campaign, ODA focused on posting Ohio specialty crops recipes on Pinterest.

Lastly, each participating retailer received a marketing manual (attached), and all participants had access to an electronic media package, including a video featuring a local producer, on the Oh So Fresh website (www.ohsofresh.org).

**Goals and Outcomes Achieved:**
The overall goal was to increase the competitive advantage of Ohio's specialty crops. One specific objective was to increase sales of Ohio Specialty crops and products by 10%. The participating stores who completed the survey after the event reported an average increase of 76% over the previous year. Another specific objective was to have at least 50 retailers/stores participate in the Oh So Fresh campaign. The promotional tool kits were shipped to 94 stores, and of those stores, 64 completed the event with in-store tastings/demos. The in-store tastings/demos educated consumers on specialty crops and allowed them to complete a survey on their buying preferences. The in-store product tastings/demos featured Ohio Specialty Crops, such as sweet corn, tomatoes, apples, apple cider, onions, green cabbage, green bell peppers, large cucumbers, zucchini, and baby carrots.

Also, there were three special events around the state. Two Ohio Apple Taste Challenges and one Ohio Pumpkin Painting Contest were held at Riesbeck Food Markets and Buehler's Fresh Foods. The Ohio Apple Taste Challenge featured four different types of Ohio apples (Golden Delicious, Cortland, Jonathan, and Honeycrisp). The Ohio Pumpkin Painting Contest featured

"We Be Little" Ohio pumpkins. 50 consumers participated in Riesbeck's (Cambridge) apple challenge; Buehler's (Ashland) apple challenge reached 100 consumers and 75 kids painted pumpkins at Buehler's (Delaware) fall event.

The goal was to have at least 250 consumer surveys completed during the campaign, and there were 271 surveys returned. One large chain was unable to complete the demos due to not having a produce director, but they did use the promotional materials and surveyed some of their customers via email.

We asked consumers two different questions. 1- Did the Oh So Fresh campaign encourage consumers to purchase Ohio grown produce and 168 people out of 228 said yes. So 73% of the consumers said the program encouraged them to purchase Ohio grown produce. 2 – Do you purchase more locally Ohio grown produce than you did one year ago? Out of 271 responses, 205 consumers said yes, so 75% of the consumers said they purchase more locally Ohio grown produce than one year ago.

**Beneficiaries:**
Direct beneficiaries consumers, grocers and producers.

| | | |
|---|---|---|
| Oh So Fresh Campaign 2013 | In-Store Tastings and Demos | 64 Stores – 271 Surveys returned |
| Oh So Fresh Campaign 2013 | Promotional Tool Kits | 94 Stores |
| October 18, 2013 – Riesbeck Food Markets, Cambridge, OH | Special Event – Ohio Apple Taste Challenge | 15 Surveys returned |
| October 25, 2013 – Buehler's Fresh Foods, Ashland, OH | Special Event – Ohio Apple Taste Challenge | 18 Surveys returned |
| October 26, 2013 – Buehler's Fresh Foods, Delaware, OH | Special Event – Ohio Pumpkin Painting | 50 children participated |
| Facebook | 319 Likes | Average reach/engagement – 91 fans |
| Twitter | 21 Followers | |
| Oh So Fresh Campaign 2014 | Promotional Materials | 21 Stores |

**Lessons Learned:**
In the consumer surveys, we asked if the Oh So Fresh Campaign encouraged the customer to purchase Ohio Grown produce and out of 228 people who answered the question, 168 responded yes. We also asked the customers if they purchase more locally Ohio Grown produce than they did a year ago. Out of 271 responses, 205 said yes. This was a very successful campaign and there are many retailers who would like to continue the campaign.

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**Additional Information:**
Website: www.ohsofresh.org
Marketing Manual is attached (with pictures of promotional materials)
Pictures from participating stores

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**FINAL REPORT**
**(Approved 12/2013)**

**Project Title: Major Weed Control Issues in Ohio Nurseries**

**Project Summary:**
Over 273 herbicide trials were set up in fields or containers at six nurseries and Christmas tree plantations: Studebaker Nurseries, New Carlisle, OH; Willoway Nurseries, Inc., Avon, OH and Willoway Nurseries, Inc., Huron, OH; North Branch Nursery, Pemberville, OH; Timbuk Farms, Granville, OH; and Decker's Nursery, Groveport, OH. 229 of these trials dealt with objectives 1 and 2 of the proposal and the remaining 44 with objective 3. Nursery visits and pre-trial surveys were conducted between December, 2012 to January, 2013 to determine current weed problems and crops, herbicide management practices and problems. These meetings determined which herbicides and crops would be evaluated in the 2013 container and field trials. The five container weeds are listed in Table 1. The current field weeds are listed in Table 2. Products were chosen to address their current issues and concerns. The total financial impact of these 273 trials is estimated at $8 Mn due to savings in four key areas, reduction in crop losses, proper herbicide use, marketing the crop sooner and reduction in cultivation, weeding and postemergence herbicide use (Table 3). Two new herbicides Marengo G and Biathlon were found safe on a variety of crops and one new spray combination, Gallery + Barricade was found safe on seven container crops, four field crops and safer than Gallery +Surflan (Table 18).

**Table 1.** Five common Ohio container weeds at six container nurseries surveyed in fall 2012.

| Common name | Scientific name | Life cycle |
|---|---|---|
| Pennsylvania bittercress | *Cardamine pennsylvanica* | Winter annual |
| Prostrate spurge | *Chamaescyce maculata* or *Euphorbia maculata* | Summer annual |
| Groundsel | *Senecio vulgaris* | Winter and summer annual |
| Pearlwort | *Sagina procumbens* | Perennial |
| Liverwort | *Marchantia polymorpha* | Perennial |

**Table 2.** Common weeds in Christmas tree plantations and nursery fields listed by family and life cycle at four nurseries or plantations surveyed in fall 2012.

| Common name | Scientific name | Division or family | Life cycle |
|---|---|---|---|
| 1. Poison ivy | *Rhus radicans* | Anacardiaceae | Perennial |
| 2. Horseweed or marestail | *Conyza canadensis* | Asteraceae | Summer or winter annual |
| 3. Prickly lettuce | *Lactuca serriola* | Asteraceae | Winter or summer or biennial |
| 4. Annual sowthistle | *Sonchus oleraceus* | Asteraceae | Summer annual |
| 5. Common groundsel | *Senecio vulgaris* | Asteraceae | Winter annual |
| 6. Musk thistle | *Carduus nutans* | Asteraceae | Biennial |
| 7. Cressleaf groundsel | *Senecio glabellus* | Asteraceae | Winter annual |
| 8. Canada thistle | *Cirsium arvense* | Asteraceae | Perennial |
| 9. Dandelion | *Taraxacum officinale* | Asteraceae | Simple perennial |
| 10. Hairy galinsoga | *Galinsoga cilata* | Asteraceae | Summer annual |
| 11. Hairy bittercress | *Cardamine hirsuta* | Brassicaceae | Winter annual |
| 12. Pennsylvania bittercress | *Cardamine pennsylvanica* | Brassicaceae | Winter annual |
| 13. Wild mustard | *Brassica kaber var. pinnatifida* | Brassicaceae | Biennial |
| 14. Amur honeysuckle | *Lonicera maackii* | Caprifoliaceae | Creeping perennial |
| 15. Birdseye pearlwort | *Sagina procumbens* | Caryophyllaceae | Perennial |
| 16. Common chickweed | *Stellaria media* | Caryophyllaceae | Winter annual |
| 17. Mouse-eared chickweed | *Ceraastium vulgartum* | *Ceraastium vulgartum* | Perennial |
| 18. Russian thistle | *Salsola iberica* | Chenopodiaceae | Annual |
| 19. Yellow nutsedge | *Cyperus esculentus* | Cyperaceae | Perennial |
| 20. Horsetail | *Equisetum arvense* | Equisetaceae | Creeping perennial |
| 21. Prostrate spurge | *Chamaescyce maculata or Eurphorbia maculata* | Eurphorbiaceae | Summer annual |
| 22. White clover | *Trifolium repens* | Leguminosae | Perennial |
| 23. Red Clover | *Trifolium pretense* | Leguminosae | Perennial |
| 24. Purple deadnettle | *Lamium purpurea* | Labiatae | Winter annual |
| 25. Henbit | *Lamium amplexicaule* | *Lamium* | Winter annual |

| | | | |
|---|---|---|---|
| | | *amplexicaule* | |
| 26. Wild garlic | *Allium vineale* | Liliaceae | Perennial |
| 27. Northern willowherb | *Epilobium ciliatum* | Onagraceae | Summer annual |
| 28. Creeping red woodsorrel | *Oxalis corniculata* | Oxalidaceae | Creeping perennial |
| 29. Annual bluegrass | *Poa annua* | Poaceae | Winter annual |
| 30. Shatter cane | *Sorghum bicolor* | Poaceae | Summer annual |
| 31. Large crabgrass | *Digitaria sanguinalis* | Poaceae | Summer annual |
| 32. Fall panicum | *Panicum dichotomiflorum* | Poaceae | Summer annual |
| 33. Yellow foxtail | *Setaria lutescens* | Poaceae | Summer annual |
| 34. Barnyard grass | *Echinochloa crusgalli* | Poaceae | Summer annual |
| 35. Quackgrass | *Elytrigia repens* | Poaceae | Creeping perennial |
| 36. Curly dock | *Rumex crispus* | Polygonaceae | Perennial |
| 37. Purslane | *Portulaca oleracea* | Portulacaceae | Summer annual |
| 38. Wild carrot | *Daucus carota* | Umbelliferae | Winter |

In the winter 2012 to Jan., 2013 surveys, liverwort was found to be one of the fastest disseminating weeds in Ohio nurseries. Even though liverwort trials were not required in the original proposal, we determined the lack of known controls for this weed warranted addition to the AGR-SCG-12-03 project. We added these liverwort trials under objective 3, regarding difficult weeds.

**Table 3.** Summary of the Specialty Crop Block Grant (SCBG) financial impact of X herbicide trials at seven nurseries in 2012-13.

| **Type of savings** | **Amount** | **No. of sites** | **Total** |
|---|---|---|---|
| Reduction of crop losses | 1.5 Mn | 2 | 3.0 Mn |
| Proper herbicide selection | 0.5 Mn | 5 | 2.0 Mn |
| Market crop sooner | 2 Mn | 2 | 2.0 Mn |
| Reduction in cultivation, weeding and postemergence herbicides | 0.25 Mn | 2 | 1.0 Mn |
| **Grand Total** | | | **8 Mn** |

**Project Approach**:

*Objective 1 and 2:*

**Container studies.** Phytotoxicity and weed control studies were carried out at four locations in Ohio including Studebaker Nurseries, North Branch Nursery, Willoway Nurseries, Inc., Avon, OH, and Willoway Nurseries, Inc., Huron, OH.

*Studebaker Nurseries*. Three species of containerized ornamentals including viburnum (*Viburnum* x'Juddi'), daylily (*Hemerocallis* 'Stella d'Oro), and hydrangea (*Hydrangea*

*paniculata* 'Little lamb') were treated on 6 May 2013. Treatments included Marengo G at 100 lb/ac, 150 lb/ac, 200 lb/ac, and 400 lb/ac; Gallery + Barricade at 1.3 lb/ac + 21 oz/ac, respectively; Biathlon at 100 lb/ac, 200 lb/ac, and 400 lb/ac; and BroadStar at 150 lb/ac. Reapplications were made approximately 6 weeks later on June 17, 2013. Hydrangea and viburnum were in #3 (3 gallon) trade size pots and daylily was in#1 (1 gallon) trade size pot at time of application.

*North Branch Nursery*. Three species of containerized ornamentals including boxwood (*Buxus sempervirens* 'Vardar Valley'), rose (*Rosa* 'Knockout') and yew (*Taxus xmedia* 'Runyon') were treated on April 23, 2013. Treatments included Marengo G at 100 lb/ac and 150 lb/ac; Gallery + Surflan (oryzalin, Dow AgroSciences) at 1.3 lb/ac + 2 qt/ac, respectively; Gallery + Surflan at 1.3 lb/ac + 1 qt/ac, respectively; Tower + Pendulum at 21 oz/ac + 2 qt/ac; Tower + Pendulum at 1 qt/ac + 1 qt/ac, respectively; Biathlon at 100 lb/ac; and F6875 (sulfentrazone + prodiamine, FMC Corp.) at 0.375 lb ai/ac, 0.75 lb ai/ac, and 1.5 lb ai/ac. Reapplications were approximately 6 weeks later on June 4, 2013. All species were in #3 trade size containers at time of application and just breaking dormancy.

*Willoway Nurseries, Huron*. Six species of containerized ornamentals including rhododendron (*Rhododendron* 'Nova Zembla'), Pieris (*Pieris* 'Red Mill'), azalea (*Azalea* x'Karen'), holly (*Ilex* X*meserveae* 'Blue Maid'), hydrangea (*Hydrangea paniculata* 'Limelight') and viburnum (*Viburnum* x'Juddi') were treated on May 1, 2013. Treatments included Marengo G at 100 lb/ac, 150 lb/ac, 200 lb/ac and 400 lb/ac; Gallery + Barricade at1.3 lb/ac + 21 oz/ac, respectively; Gallery + Surflan at 1.3 lb/ac + 1 qt/ac, respectively; Tower + Pendulum at 21 oz/ac + 2 qt/ac, respectively; Tower + Pendulum at 1 qt/ac + 1 qt/ac, respectively; Biathlon at 100 lb/ac, 200 lb/ac, and 400 lb/ac; BroadStar at 150 lb/ac; and Gallery + Ronstar (oxadiazon, Bayer Corp.) at 1 lb/ac + 2 lb/ac, respectively. Reapplications were made approximately 8 weeks later on June 26, 2013. Rhododendron and Pieris were in #1 size pots, azalea and holly were in #2 size pots, and viburnum and hydrangea were in #3 size pots at time of application. All species had broken dormancy by time of first application. Due to a nutrient problem, the trials at Willoway Nurseries were terminated. Data taken at 1 WA2T, was corrupted due to the nutrient issues at the site, and is not presented.

*Willoway Nurseries, Avon*. Four species of containerized ornamentals including two cultivars of hydrangea (*Hydrangea macrophylla* 'Endless summer' and *Hydrangea arborescens* 'Invincible spirit') rose (*Rosa* 'Knockout'), and Itea (*Itea* 'Little Henry') were treated on April 19, 2013 with the exception of the 'Endless summer' hydrangea, which was treated on 1 May 2013. Treatments included Marengo G at 100 lb/ac; Gallery + Surflan at 1 lb/ac + 1 qt/ac, respectively; Tower + Pendulum at 21 oz/ac + 2 qt/ac, respectively; Tower + Pendulum at 1 qt/ac + 1 qt/ac, respectively; Biathlon at 100 lb/ac; FreeHand at 150 lb/ac; Regal O-O at 100 lb/ac; and Jewel at 100 lb/ac. Reapplications were made on June 26, 2013. All species were in #3 containers at time of application and had broken dormancy. Due to a nutrient problem, the trials at Willoway

Nurseries were terminated. Data taken at 1 WA2T, was corrupted due to the nutrient issues, and is not presented.

*At all locations, liquid applications were applied via $CO_2$ backpack sprayer delivering 25 gal/ac and granular formulations were applied via handheld shaker jars.* Phytotoxicity visual ratings were based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable. Treatments at Studebaker Nurseries and Willoway Nurseries were evaluated at 1 WAT, 2 WAT, 4 WAT, and 1 WA2T; evaluations at North Branch were done 1 WAT, 2 WAT, 4 WAT, 1 WA2T, 2 WA2T, and 4 WA2T. For phytotoxicity, treatment means were compared to a control using Dunnett's t-test with $\alpha = 0.10$ and 0.05 using Proc Mixed in SAS® software.

**Field studies**. Several trials were conducted to determine weed control and phytotoxicity from several herbicides and herbicide combinations at three locations in Ohio, which included Studebaker Nurseries, Inc., New Carlisle, OH; North Branch Nursery, Inc., Pemberville, OH, and Timbuk Farms, Granville, OH. Species at Studebaker Nurseries included boxwood (*Buxus* 'Green velvet') and yew (*Taxus densiformus*). Species at North Branch Nursery included eastern white pine (*Pinus strobus*) and white spruce (*Picea glauca*), and at Timbuk Farms, Canaan fir (*Abies balsamea var phanerolepis). Liquid applications were applied via $CO_2$ backpack sprayer delivering 25 gal/ac and granular formulations were applied via handheld shaker jars. At each location, the rows were hoed just prior to first treatment application.*

*Studebaker Nurseries. Treatments were applied at Studebaker Nurseries on May 6, 2013 and included V-10366 (flumioxazin + pyroxasulfone, Valent U.S.A.) at 7.5, 15, and 30 oz/ac, Tower + Pendulum Aquacap (dimethenamid-p + pendulum, both from BASF Corp.) at 32 oz/ac + 2 qt/ac, respectively, and SureGuard (flumioxazin, Valent U.S.A.) at 6 oz and 12 oz/ac. Treatments were reapplied on June 17, 2013. Liquid applications were applied as directed sprays. For both boxwood and yew, there were four replications/treatment and three subsamples/replication arranged in a completely randomized design in the liner field for each species. Treatments were evaluated at 1 WAT (weeks after treatment) 2 WAT, 4 WAT and 1 WA2T (weeks after second treatment).*

*North Branch Nursery. Treatments were applied at North Branch on April 23, 2013 and included Gallery (isoxaben, Dow AgroSciences) + Barricade (Syngenta Crop Protection, Inc.) at 1.3 lb/ac + 21 oz/ac, respectively; Tower + Pendulum at 21 oz/ac + 2 qt/ac, respectively; Tower + Pendulum at 1 qt/ac + 1 qt/ac, respectively; Biathlon (oxyfluorfen + prodiamine, OHP, Inc.) at 100 lb/ac; Marengo G (indaziflam, OHP, Inc.) at 150 lb/ac; V-10366 at 15 oz/ac; and SureGuard at 6 oz/ac. Treatments were reapplied on June 4, 2013. Liquid applications were applied as directed sprays. For each species, there were four replications with three subsamples/replication for each treatment in a completely randomized design within each species. Treatments were evaluated at 1 WAT, 2 WAT, 4 WAT, 1 WA2T, 2 WA2T, and 4 WA2T.*

*Timbuk Farms. Treatments were applied at Timbuk Farms on July 9, 2013 and included the same treatments describe above for North Branch Nursery, and the treatments were reapplied on September 3, 2013. At Timbuk, one species,* Canaan Fir, Abies *balsamea* var phanerolepis also known as West Virginia fir was used. However, *there were two growth stages evaluated, which were newly planted and trees in the ground for three years. Studies were also conducted in the fall of 2012 with three growth stages, newly planted, 3 years old and trees in the ground 5 years. The results of the fall 2012 study were presented with the SCBG 11-08 project. Treatments were applied over-the-top of the newly planted trees and as directed applications for the older trees. For each growth stage, there were three subsamples/replication with four replications/treatment randomized in a completely randomized design. Treatments were evaluated at 1 WAT, 2 WAT, 3 WAT, 4 WAT, 1 WA2T, and 2 WA2T.*

*At all locations,* phytotoxicity visual ratings were based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable. Efficacy visual ratings were based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable. For phytotoxicity, treatment means were compared to a control using Dunnett's t-test with $\alpha$ = 0.10 and 0.05 using Proc Mixed in SAS® software. For efficacy, treatment means were compared using lsmeans in Proc Mixed with $\alpha$ = 0.05.

*Objective 3:*

**Liverwort trials.** Trials were initiated at Decker's Nursery, Inc., Groveport, OH on February 28, 2013 in a covered hoop house that had minimum heat to protect plants from frost. Liquid applications of SureGuard (flumioxazin, Valent U.S.A) at 3 oz and 4 oz/ac; WeedPharm (20% acetic acid, Pharm Solutions, Inc.) at 10% v/v; and Marengo SC (indaziflam, Bayer Corp.) at 9 oz/ac were applied with a $CO_2$ backpack sprayer delivering 50 gal/ac. A 100 gal/ac rate was desired, so two passes were made at each application. Treatments of baking soda and reagent grade potassium bicarbonate (Sigma-Aldrich Corp.) were also each applied at approximately 2.24 g/ft$^2$ with a Dustin-Mizer or handheld shaker jar. A second application was made on April 26, 2013. For phytotoxicity, ornamental species included barberry (*Berberis* 'Orange Rocket'), boxwood (*Buxus microphylla* 'Winter gem'), hydrangea (*Hydrangea arborescens* 'Incrediball'), and Physocarpus (*Physocarpus* 'Summer wine'). Evaluations of efficacy and phytotoxicity were conducted at 1 WAT (weeks after treatment), 2 WAT, 4 WAT, 8 WAT, 1 WA2T (weeks after second treatment), 2 WA2T, and 4 WA2T. Phytotoxicity visual ratings were based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable. Efficacy visual ratings were based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable. The trial was set up as a completely randomized design for each species with three replications/treatment and three subsamples/replication. For phytotoxicity, treatment means were compared to a control using Dunnett's t-test with $\alpha$ = 0.10 and 0.05 using Proc Mixed in SAS® software. For efficacy, treatment means were compared using lsmeans in Proc Mixed with $\alpha$ = 0.05.

***Difficult weeds. Rorippa* trials.** Addressing objective 3, in pre- project start surveys we found that liner bed growers were using the following herbicides, Rout, Barricade, Snapshot, SureGuard, Pendulum, Round up, Goal, Tower, Lontrel and 2, 4-D. On average, they were spending $2300.00/ ac to hand weed problem areas with difficult weeds such as *Rorippa.* We had targeted to reduce their weed program cost by 30%. We accomplished this goal. The acceptable use of Lontrel in this study provided 35% control, thus reducing hand weeding costs by 35%. We recommend more work with Lontrel on more species and with lower rates to reduce phytotoxicity.

Two trials were conducted in fields, one as a preemergence study, and the other a postemergence study. Evaluations for the pre- and post- emergence trials consisted of visual ratings of weed control and phytotoxicity to crop species. Visual ratings of weed control were based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable. Visual ratings of phytotoxicity were based on a scale of 0-10 with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable. Data was analyzed using SAS® GLM. Phytotoxicity effects of treatments were compared to the controls using Dunnett's t-test ($\alpha = 0.10$ and 0.05). Efficacy treatments were compared to each other using least significance difference (ls means).

The preemergence trial was started on April 4, 2013 in a liner bed of Common purple lilacs (*Syringa vulgaris*) that had not yet broken dormancy and were approximately 6" (15 cm) tall. Weather at time of application was sunny, approximately 40 °F with no dew present. Six herbicides and one herbicide + mulch were compared to an untreated control. Herbicides included Corsair (chlorsulfuron, Nufarm Americas, Inc.) at 5.3 oz/ac, Certainty (sulfosulfuron, Monsanto Corp.) at 1 oz/ac, SedgeHammer (halosulfuron, Gowan Co.) at 2 oz/ac, Lontrel (clopyralid, Dow Agro Sciences) at 1 pt/ac, V-10336 (no trade name yet, flumioxazin + pyroxasulfone, Valent U.S.A.) at 15 oz/ac, and Diuron 80 (diuron, Drexel, Inc.) at 3 lb./ac. For the herbicide + mulch treatment, Casoron CS (dichlobenil, Chemtura Corp.) at 3 gal/ac was applied just prior to application of 2 inches of pine nugget mulch. The herbicides were applied with a $CO_2$ backpack sprayer delivering 25 gal/ac. The creeping yellow cress was just beginning to green below the soil surface. Plots were approximately 3' x 3' with approximately 1-2' between plots.

The postemergence trial treatments were also conducted on Common purple lilacs (*Syringa vulgaris*); however, unlike the preemergence trial, the lilacs had broken dormancy at the time of application and were approximately 7" (17.5 cm) tall. Applications were made on May 16, 2013. Weather was approximately 65 °F, 5 mph wind, sunny. Herbicides included: Corsair (chlorsulfuron, Nufarm Americas, Inc.) at 5.3 oz/ac, Certainty (sulfosulfuron, Monsanto Corp.) at 1 oz/ac, SedgeHammer (halosulfuron, Gowan Co.) at 2 oz/ac, Lontrel (clopyralid, Dow Agro Sciences) at 1 pt/ac, V-10336 (no trade name yet, flumioxazin + pyroxasulfone, Valent U.S.A.) at 15 oz/ac, Diuron 80 (diuron, Drexel, Inc.) at 3 lb/ac, Classic (chlorimuron, Dupont Crop Protection) at 2/3 oz/ac, and Marengo SC at 9 oz/ac. All treatments included the addition of

nonionic surfactant at 0.25% v/v. Herbicides were applied with a $CO_2$ backpack sprayer delivering 25 gal/ac.

**Goals and Outcomes Achieved:**

Objective 1 & 2:

**Container results.**

*Studebaker Nurseries.* Marengo G was phytotoxic to all three species; however, daylily injury was at commercially acceptable levels (Fig. 1A) for all dates and rates and decreased after the second application (Table 4). Marengo G injury to *Hydrangea paniculata*, however, was not commercially acceptable and continued after the second application (Table 4) (Fig. 2 C). We speculate that the 200 lb. rate of Marengo was never applied. Marengo injury to *Viburnum* X 'Juddi' was the least of the three species evaluated and was commercially acceptable at all rates after the first application. The second application, however, significantly increased injury at all rates after the second application and was not commercially acceptable at 400 lb./ac 1WA2T (Table 4).

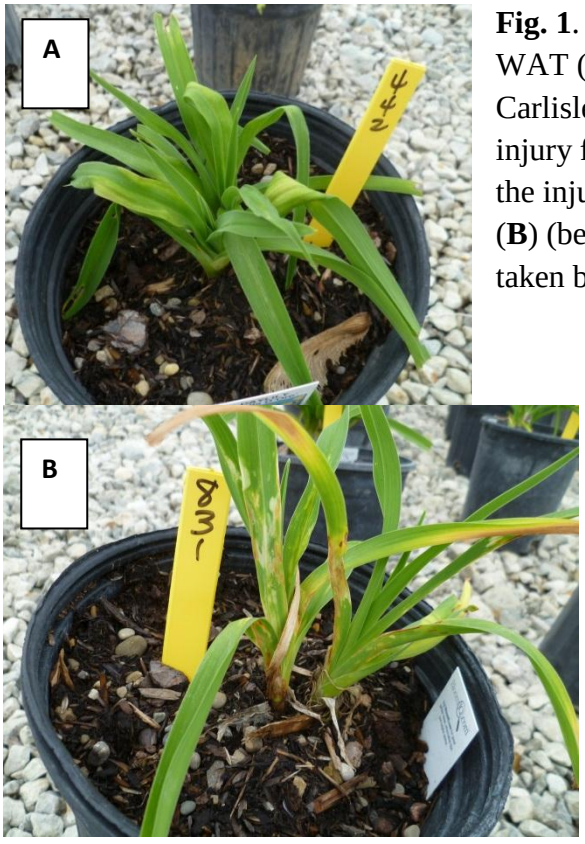
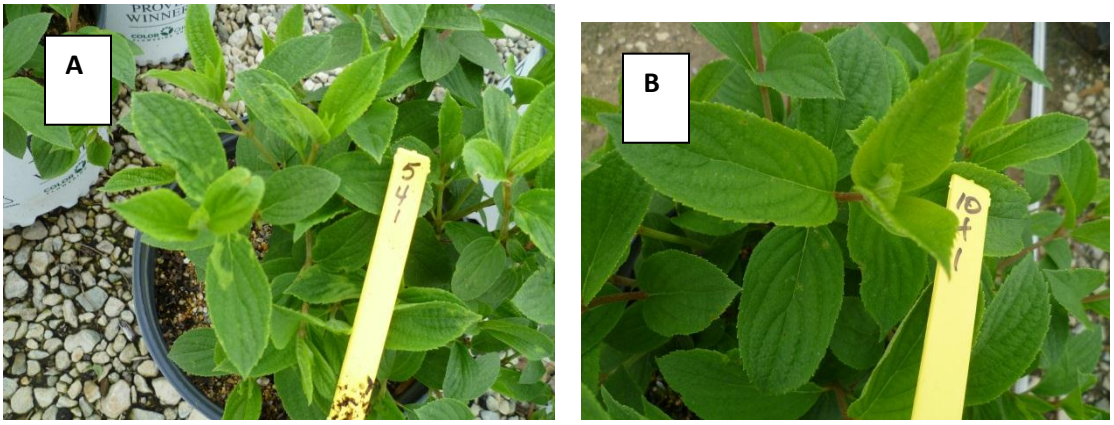




**Fig. 1**. **A, B and C**. (**A)** (left) Marengo G at 400 lb/ac 2 WAT (2.4 rating) at Studebaker Nurseries, Inc., New Carlisle, OH on *Hemerocallis* 'Stella d'Oro' although the injury from Marengo is significant it is far less severe than the injury caused by Biathlon 400 lb/ac 2WAT (rating 5.4) (**B**) (below) or Broadstar (150 lb/ac) (**C**) (below). (pictures taken by H. Mathers).

Gallery + Barricade showed some passing phytotoxicity to *Hydrangea paniculata (*Fig. 2 A) and inconsistent injury on *Viburnum* X 'Juddi' compared to the control (Fig. 2 B). Gallery + Barricade did not injury *Hemerocallis* 'Stella d'Oro' (Table 4). Biathlon did cause significant injury on *Hemerocallis* 'Stella d'Oro' at 200 and 400 lb rates (Fig. 1B); although, by the end of the trial only the 400 lb rate showed not commercially acceptable injury (Table 4). With *Viburnum* X 'Juddi', Biathlon at 100 lb /ac showed significant injury but only at 4 WAT and 1

WA2T. *Hydrangea paniculata* had significant injury caused by the 200 and 400 lb rates of Biathlon; however, this injury decreased over time (Table 4).




C

**Fig. 2 A, B and C.** (A). (Above) Gallery + Surflan, 2 WAT on *Hydrangea paniculata 'Little Lamb'* at Studebaker Nurseries, Inc., New Carlisle, OH (rating 3.7). (B) (above) Control at 2 WAT showing no damage on *Hydrangea paniculata 'Little Lamb'* and (C) (left) Marengo at 400 lb/ac (rating 5.3) 2 WAT, severe leaf distortion, puckering, burn and chlorosis. (Pictures taken by H. Mathers)

**Fig. 3.** (Center of picture) BroadStar applied on *Viburnum* X 'Juddi' 4 3) showing severe stunting compared treated pots and general chlorosis at Nurseries, Inc., New Carlisle, OH. by H. Mathers).

BroadStar caused significant injury that was not commercially acceptable on *Hemerocallis* 'Stella d'Oro' (Fig. 1 C) and *Hydrangea paniculata. With Viburnum* X 'Juddi' the BroadStar caused injury that was commercially unacceptable after second application (Table 4) (Fig.3).

150 lb/ac WAT (rating to surrounding Studebaker (Picture taken

**Table 4.** Phytotoxicity of several herbicides on selected containerized ornamentals at Studebaker Nurs

*Hemerocallis* 'Stella d'Oro'

| Treatment | Rate/ac | 1 WAT | | 2 WAT | |
|---|---|---|---|---|---|
| Marengo G | 100 lb | 2.6 | | 2.7 | ** |
| Marengo G | 150 lb | 1.4 | | 2.7 | ** |
| Marengo G | 200 lb | 1.9 | | 1.1 | |
| Marengo G | 400 lb | 0.5 | | 2.4 | ** |
| Gallery + Barricade | 1.3 lb + 21 oz | 1.5 | | 0.8 | |
| Biathlon | 100 lb | 1.8 | | 0.9 | |
| Biathlon | 200 lb | 1.5 | | 2.9 | ** |
| Biathlon | 400 lb | 3.1 | ** | 5.4 | ** |
| BroadStar | 150 lb | 4.0 | ** | 5.1 | ** |
| Untreated | -- | 1.1 | | 0.8 | |

*Hydrangea paniculata* 'Little Lamb'

| Treatment | Rate/ac | 1 WAT | | 2 WAT | |
|---|---|---|---|---|---|
| Marengo G | 100 lb | 3.3 | ** | 3.3 | ** |
| Marengo G | 150 lb | 4.2 | ** | 4.6 | ** |
| Marengo G | 200 lb | 0.9 | | 0.7 | |
| Marengo G | 400 lb | 4.8 | ** | 5.3 | ** |
| Gallery + Barricade | 1.3 lb + 21 oz | 0.5 | | 3.7 | ** |
| Biathlon | 100 lb | 0.3 | | 0.6 | |
| Biathlon | 200 lb | 2.7 | ** | 1.8 | ** |
| Biathlon | 400 lb | 3.4 | ** | 2.3 | ** |
| BroadStar | 150 lb | 4.8 | ** | 4.7 | ** |
| Untreated | -- | 0.0 | | 0.1 | |

*Viburnum x*'Juddi'

| Treatment | Rate/ac | 1 WAT | | 2 WAT | |
|---|---|---|---|---|---|
| Marengo G | 100 lb | 0.7 | | 0.2 | |
| Marengo G | 150 lb | 1.6 | | 1.3 | * |
| Marengo G | 200 lb | 0.6 | | 0.2 | |
| Marengo G | 400 lb | 1.9 | | 1.7 | ** |
| Gallery + Barricade | 1.3 lb + 21 oz | 1.8 | | 2.1 | ** |
| Biathlon | 100 lb | 1.1 | | 1.2 | |

| | | | |
|---|---|---|---|
| Biathlon | 200 lb | 2.0 * | 0.6 |
| Biathlon | 400 lb | 1.0 | 0.6 |
| BroadStar | 150 lb | 1.7 | 1.5 ** |
| Untreated | -- | 0.9 | 0.2 |

z = weeks after treatment

y = visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = visual ratings followed by *, ** are significantly different from the control based on Dunnett's t-test (α = 0.10 and 0.05, re

*North Branch Nursery.* Marengo G was safe at 150 and 200 lb/ac with all three species evaluated (Table 5). Gallery + Surflan was safe at 1.3 lb + 2 qt and 1.3 lb + 1 qt with *Buxus sempervirens* 'Vardar Valley' and *Taxus xmedia* 'Runyon'; however, Rosa 'Knock out' was severely injured by both rates (Table 5), concurring with our results from the 2011-08 SCBG. Although the rose grew out of the severe stunting caused by the first application (Fig. 4 A) and was not increased after the second application (Table 5). Random mottling typical of Gallery injury persisted 2 weeks (Fig. 4B) and 4 weeks following the second application (Table 5).

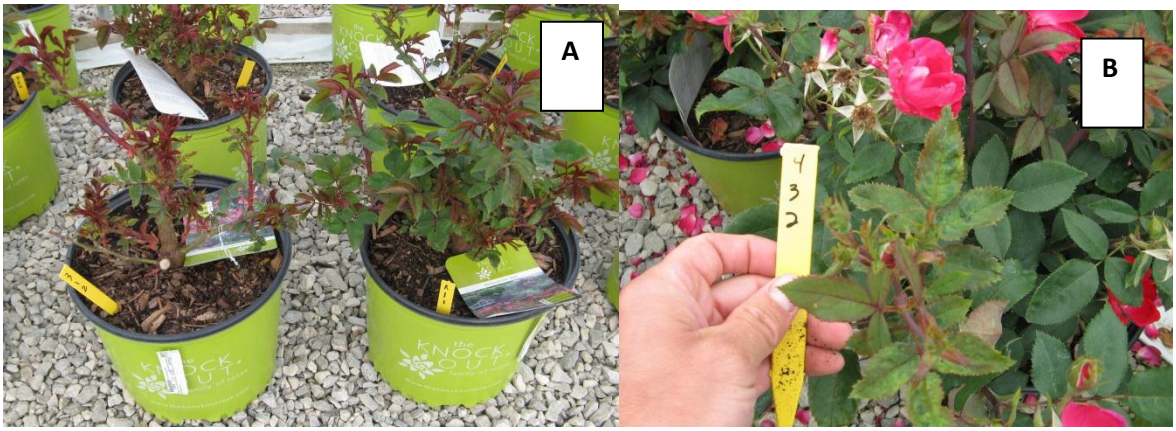



**Fig. 4 A and B.** (A) (above - left) Gallery + Surflan at 1.3 lb + 2 qt 2 WAT at North Branch Nursery, Pemberville, OH on *Rosa* 'Knock out' (rating 5.3) and (B) (above-right) 1.3 lb + 1 qt. 2 WAT2T (rating 1.6).

Tower + Pendulum (1qt + 1qt) provided some injury on after the first application (Table 5) and no injury to *Taxus xmedia* 'Runyon' at any date. The Tower + Pendulum (21 oz + 2 qt) rate, with 11 less ounces of dimethamid- p but 32 ounces more of pendimethalin did not cause commercial injury to *Buxus sempervirens* 'Vardar Valley' (Fig. 5 B) or *Taxus xmedia* 'Runyon' (Table 5). The Tower + Pendulum (1qt + 1qt) injury on Buxus caused an injury rating of 2.3, 2 WAT (Fig. 5 B); however, the injury decreased over time and was not different from the control by 1WA2T (Table 5). Tower + Pendulum at both rates severely injured rose; however, the (1qt + 1 qt) (3.3, 2 WAT) (Fig. 5 A – far right) was slightly worse than the (21 oz + 2 qt) (3.9 2 WAT) injury (Fig. 5 A – center). The Tower + Pendulum injury was most severe after the first application (Fig. 5A)

but was still noticeable by the end of the trial (Table 5) with the oldest leaves still appearing mottled. The extra Tower with both these species caused slightly more injury than extra pendulum being added to the combination.


**Fig. 5 A and B.** A. (above - left) *Rosa* 'Knock out' treated from left to right (Marengo, Tower + Pendulum (21 oz + 2 qt) and Tower + Pendulum (1qt + 1qt) 2 WAT at North Branch Nursery, Pemberville, OH. Note the lack of growth caused by both rates of Tower + Pendulum compared to the Marengo treated rose. (B) (above – right) *Buxus sempervirens* 'Vardar Valley' treated from left to right (Control, Tower + Pendulum (21 oz + 2 qt) and Tower + Pendulum (1qt + 1qt) 2 WAT at North Branch Nursery, Pemberville, OH. Note the injury from the Tower + Pendulum (1qt + 1qt) is greater than from the (21 oz + 2 qt). (Pictures by H. Mathers).

F6875 was not injurious to *Taxus xmedia* 'Runyon' at any rate tested (Table 5). *Rosa* 'Knock out' or *Buxus sempervirens* 'Vardar Valley' were not injured by F6875 at the lowest rate of application (Table 5). However, F6875 did cause injury to *Buxus sempervirens* 'Vardar Valley' and *Rosa* 'Knock out' at the 2X and 4X rates (Table 5). This injury was worst after the first application and on rose (Fig. 6 A and B). The second application did not increase the injury; however, some injury persisted from the first application at the highest rate on rose by 2WA2T (Table 5).

**Fig. 6 A and B.** (A) *Buxus sempervirens* 'Vardar Valley', from left to right control 1X, 2X and 4X of F6875 at North Branch Nursery, Pemberville, OH. Note the injury from the 4X rate is the worst. (B) *Rosa* 'Knock out', from left to right 1X, 2X (rating 2.3) and 4X (rating 2.3) of F6875. Note the injury on rose is equal whether the rate is 2X or 4X.

**Table 5.** Phytotoxicity of several herbicides on selected containerized ornamentals at North Branch Nursery, Pemberville, OH. Trial initiated April 23, 2013.

*Buxus sempervirens* 'Vardar Valley'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT | 1 WA2T | 2 WA2T | 4 WA2T |
|---|---|---|---|---|---|---|---|
| Marengo G | 150 lb | 0.3 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| Marengo G | 200 lb | 0.3 | 0.1 | 0.4 | 0.6 | 0.4 | 0.0 |
| Gallery + Surflan | 1.3 lb + 2 qt | 0.3 | 0.1 | 0.2 | 0.5 | 0.4 | 0.0 |
| Gallery + Surflan | 1.3 lb + 1 qt | 0.3 | 0.0 | 0.2 | 0.8 | 0.7 | 0.2 |
| Tower + Pendulum | 21 oz + 2 qt | 0.4 | 0.1 | 0.8 | 0.9 | 0.8 | 0.4 |
| Tower + Pendulum | 1 qt + 1 qt | 1.6 ** | 2.3 ** | 1.7 ** | 0.6 | 0.3 | 0.3 |
| Biathlon | 100 lb | 0.4 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 |
| F6875 | 0.375 lb ai | 0.1 | 0.1 | 0.2 | 0.5 | 0.3 | 0.1 |
| F6875 | 0.75 lb ai | 0.7 | 0.9 ** | 1.4 ** | 1.0 | 0.5 | 0.8 |
| F6875 | 1.5 lb ai | 1.3 ** | 2.0 ** | 2.8 ** | 2.7 ** | 2.3 ** | 2.2 ** |
| Untreated | -- | 0.1 | 0.0 | 0.0 | 0.5 | 0.3 | 0.0 |

*Taxus xmedia* 'Runyon'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT | 1 WA2T | 2 WA2T | 4 WA2T |
|---|---|---|---|---|---|---|---|
| Marengo G | 150 lb | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 |
| Marengo G | 200 lb | 0.3 | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 |
| Gallery + Surflan | 1.3 lb + 2 qt | 0.4 | 0.2 | 0.0 | 0.1 | 0.3 | 0.4 |
| Gallery + Surflan | 1.3 lb + 1 qt | 0.3 | 0.1 | 0.0 | 0.4 | 0.3 | 0.0 |
| Tower + Pendulum | 21 oz + 2 qt | 0.2 | 0.3 | 0.0 | 0.3 | 0.4 | 0.8 |
| Tower + Pendulum | 1 qt + 1 qt | 0.5 | 0.5 | 0.0 | 0.0 | 0.3 | 0.1 |
| Biathlon | 100 lb | 0.4 | 0.5 | 0.0 | 0.2 | 0.1 | 0.0 |
| F6875 | 0.375 lb ai | 0.4 | 0.1 | 0.0 | 0.1 | 0.2 | 0.0 |
| F6875 | 0.75 lb ai | 0.3 | 0.2 | 0.0 | 0.1 | 0.0 | 0.1 |
| F6875 | 1.5 lb ai | 0.8 | 0.3 | 0.0 | 0.3 | 0.4 | 0.3 |
| Untreated | -- | 0.2 | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 |

*Rosa* 'Knockout'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT | 1 WA2T | 2 WA2T | 4 WA2T |
|---|---|---|---|---|---|---|---|
| Marengo G | 150 lb | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.4 |
| Marengo G | 200 lb | 0.3 | 0.0 | 0.0 | 0.3 | 0.4 | 0.8 |
| Gallery + Surflan | 1.3 lb + 2 qt | 3.1 ** | 5.3 ** | 2.9 ** | 2.8 ** | 1.9 ** | 0.8 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gallery + Surflan | 1.3 lb + 1 qt | 3.4 | ** | 5.3 | ** | 2.1 | ** | 2.7 | ** | 1.6 | ** | 0.9 | | | |
| Tower + Pendulum | 21 oz + 2 qt | 3.2 | ** | 3.3 | ** | 0.3 | | 2.8 | ** | 1.4 | ** | 1.2 | * | | |
| Tower + Pendulum | 1 qt + 1 qt | 3.7 | ** | 3.9 | ** | 1.4 | ** | 2.4 | ** | 1.2 | ** | 0.8 | | | |
| Biathlon | 100 lb | 2.7 | ** | 0.8 | | 0.5 | | 0.5 | | 0.3 | | 0.2 | | | |
| F6875 | 0.375 lb ai | 0.8 | | 0.0 | | 0.1 | | 2.0 | ** | 0.8 | | 0.5 | | | |
| F6875 | 0.75 lb ai | 3.8 | ** | 2.3 | ** | 0.7 | | 2.9 | ** | 1.8 | ** | 0.4 | | | |
| F6875 | 1.5 lb ai | 3.3 | ** | 2.3 | ** | 1.2 | ** | 3.5 | ** | 1.7 | ** | 0.8 | | | |
| Untreated | -- | 0.6 | | 0.2 | | 0.0 | | 0.0 | | 0.1 | | 0.3 | | | |

z = weeks after treatment

y = visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = visual ratings followed by *, ** are significantly different from the control based on Dunnett's t-test ($\alpha$ = 0.10 and 0.05, respectively).

*Willoway Huron.* Marengo G caused no injury to *Rhododendron* 'Nova Zembla', *Pieris* 'Red Mill', *Azalea* x'Karen' or *Hydrangea paniculata* 'Limelight'. Marengo did cause some slight, transient injury on *Ilex* X*meserveae* 'Blue Maid' at the 200 lb/ ac rate and some injury on *Viburnum* x'Juddi' that was never significantly greater than the control at 150 and 200lb/ac. This concurs with last year's results where Marengo was safe on a wide variety of materials but could only be safely used on Viburnum at a 1X rate.

Gallery + Barricade (1.3 lb + 21 oz) was not injurious to any to the species and Gallery + Surflan (1.3 lb + 1 qt) was also not injurious to any non-commercially acceptable level with the exception of *Hydrangea paniculata* 'Limelight' (Table 6). *Hydrangea paniculata* 'Limelight' injury was most severe at 1 WAT (rating 2.6).

Tower + pendulum at the 21 oz/ac + 2 qt/ac rate provided no injury to *Rhododendron* 'Nova Zembla' and *Ilex* X*meserveae* 'Blue Maid'; however, injury was noticeable on *Azalea* x'Karen' (Fig. 7 C), *Hydrangea paniculata* 'Limelight' (Fig. 7 A) and *Viburnum* x'Juddi' (Table 6). Tower + Pendulum at the 1 qt/ac + 1qt/ac rate was also injurious to *Azalea*, *Viburnum* and *Hydrangea* (Fig. 7 B) as it was with 21 oz + 2 qt rate; however, the addition of 11 more ounces of Tower also picked up injury *Pieris* (Table 6). *Azalea* x'Karen' and *Hydrangea paniculata* 'Limelight' were the two species with the most injury from tower + pendulum and in the Azalea the injury from the 21 oz/ac + 2 qt/ac rate caused more injury (Fig. 7C) (Table 6). This was different than at North Branch Nursery where the 1qt/ac + 1 qt/ac rate caused more injury on rose and boxwood. Neither rate of Tower +pendulum should be used on *Hydrangea* or *Azalea.*


**Fig. 7 A, B and C. (A)** (above-left) Tower + Pendulum on *Hydrangea paniculata* 'Limelight' at 21 oz + 2 qt/ ac rate 2 WAT at Willoway Nursery, Huron, OH and (**B**) (above-right) Tower + Pendulum on *Hydrangea paniculata* 'Limelight at 1 qt/ac + 1qt/ac rate 2 WAT. Note the injury is very comparable at both rates. (**C**) (Left) *Azalea* x'Karen' 6 WAT showing control (left in picture) and Tower + Pendulum at 21 oz + 2 qt/ ac at Willoway, Huron, OH.

Biathlon at (100, 200 or 400 lb/ac) and BroadStar at 150 lb/ ac did not injure any of the six species evaluated (Table 6). This was similar to last year where we only found injury from Biathlon on Daylily. The Gallery + Ronstar also caused no injury (Table 6).


*Rhododendron* 'Nova Zembla'

**Table 6.** Phytotoxicity on selected ornamentals from several herbicides at Willoway Nurseries, Huron, OH the trial was initiated on May 1, 2013.

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT |
|---|---|---|---|---|
| Marengo G | 100 lb | 0.0[yx] | 0.3 | 0.8 |
| Marengo G | 150 lb | 0.0 | 0.3 | 0.6 |
| Marengo G | 200 lb | 0.0 | 0.0 | 0.8 |
| Marengo G | 400 lb | 0.0 | 0.0 | 0.3 |
| Gallery + Barricade | 1.3 lb + 21 oz | 0.0 | 1.0 | 1.3 |
| Gallery + Surflan | 1.3 lb + 1 qt | 1.7 ** | 1.5 ** | 0.8 |
| Tower + Pendulum | 21 oz + 2 qt | 0.0 | 0.0 | 1.2 |
| Tower + Pendulum | 1 qt + 1 qt | 0.0 | 0.0 | 0.6 |
| Biathlon | 100 lb | 0.0 | 0.0 | 0.3 |
| Biathlon | 200 lb | 0.0 | 0.3 | 0.5 |
| Biathlon | 400 lb | 0.0 | 0.2 | 0.0 |
| BroadStar | 150 lb | 0.0 | 0.0 | 0.0 |
| Gallery + Ronstar WSP | 1 lb + 2 lb | 0.0 | 0.3 | 0.3 |
| Untreated | -- | 0.0 | 0.1 | 0.6 |

*Azalea* 'Karen'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT |
|---|---|---|---|---|
| Marengo G | 100 lb | 1.1 | 1.4 | 1.3 |
| Marengo G | 150 lb | 0.0 ** | 0.0 | 0.3 |
| Marengo G | 200 lb | 0.5 | 0.8 | 1.1 |
| Marengo G | 400 lb | 1.0 | 1.0 | 0.9 |
| Gallery + Barricade | 1.3 lb + 21 oz | 0.4 | 1.3 | 0.6 |
| Gallery + Surflan | 1.3 lb + 1 qt | 0.4 | 2.0 * | 1.6 |
| Tower + Pendulum | 21 oz + 2 qt | 2.2 * | 3.6 ** | 5.1 ** |
| Tower + Pendulum | 1 qt + 1 qt | 1.2 | 4.2 ** | 4.2 ** |
| Biathlon | 100 lb | 1.0 | 1.3 | 0.3 |
| Biathlon | 200 lb | 0.3 | 0.4 | 0.3 |
| Biathlon | 400 lb | 0.3 | 0.5 | 0.8 |
| BroadStar | 150 lb | 0.3 | 0.2 | 0.3 |
| Gallery + Ronstar WSP | 1 lb + 2 lb | 0.0 ** | 0.5 | 0.3 |
| Untreated | -- | 1.2 | 0.6 | 0.4 |

*Pieris* 'Red Mill'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT |
|---|---|---|---|---|
| Marengo G | 100 lb | 0.0 | 0.0 | 0.0 |
| Marengo G | 150 lb | 0.0 | 0.0 | 0.0 |
| Marengo G | 200 lb | 0.0 | 0.0 | 0.0 |
| Marengo G | 400 lb | 0.0 | 0.0 | 0.3 |
| Gallery + Barricade | 1.3 lb + 21 oz | 0.0 | 0.0 | 0.3 |
| Gallery + Surflan | 1.3 lb + 1 qt | 0.0 | 0.0 | 0.5 |
| Tower + Pendulum | 21 oz + 2 qt | 0.0 | 1.7 ** | 1.3 ** |
| Tower + Pendulum | 1 qt + 1 qt | 0.0 | 2.9 ** | 2.7 ** |
| Biathlon | 100 lb | 0.0 | 0.0 | 0.0 |
| Biathlon | 200 lb | 0.0 | 0.0 | 0.0 |
| Biathlon | 400 lb | 0.0 | 0.3 | 0.1 |
| BroadStar | 150 lb | 0.0 | 0.0 | 0.0 |
| Gallery + Ronstar WSP | 1 lb + 2 lb | 0.0 | 0.0 | 0.1 |
| Untreated | -- | 0.0 | 0.0 | 0.0 |

*Ilex* X*meserveae* 'Blue Maid'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT |
|---|---|---|---|---|
| Marengo G | 100 lb | 0.0 | 0.0 | 0.0 |
| Marengo G | 150 lb | 0.0 | 0.0 | 0.3 |
| Marengo G | 200 lb | 1.3 ** | 0.6 ** | 0.3 |
| Marengo G | 400 lb | 0.0 | 0.0 | 0.0 |
| Gallery + Barricade | 1.3 lb + 21 oz | 0.0 | 0.0 | 0.0 |
| Gallery + Surflan | 1.3 lb + 1 qt | 1.3 ** | 0.0 | 0.0 |
| Tower + Pendulum | 21 oz + 2 qt | 0.0 | 0.0 | 0.2 |
| Tower + Pendulum | 1 qt + 1 qt | 0.0 | 0.0 | 0.3 |
| Biathlon | 100 lb | 0.0 | 0.0 | 0.0 |
| Biathlon | 200 lb | 0.0 | 0.0 | 0.0 |
| Biathlon | 400 lb | 0.0 | 0.0 | 0.0 |
| BroadStar | 150 lb | 0.0 | 0.0 | 0.0 |
| Gallery + Ronstar WSP | 1 lb + 2 lb | 0.0 | 0.0 | 0.0 |
| Untreated | -- | 0.0 | 0.0 | 0.0 |

*Viburnum* x'*Juddi*'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT |
|---|---|---|---|---|
| Marengo G | 100 lb | 1.6 | 0.6 | 1.0 |
| Marengo G | 150 lb | 1.5 | 2.1 | 2.2 |
| Marengo G | 200 lb | 1.8 | 1.8 | 2.9 |
| Marengo G | 400 lb | 1.1 | 0.9 | 1.4 |
| Gallery + Barricade | 1.3 lb + 21 oz | 1.1 | 0.2 | 0.3 |
| Gallery + Surflan | 1.3 lb + 1 qt | 0.7 | 0.8 | 1.4 |
| Tower + Pendulum | 21 oz + 2 qt | 1.7 | 2.3 | 3.4 ** |
| Tower + Pendulum | 1 qt + 1 qt | 0.8 | 1.8 | 2.6 |
| Biathlon | 100 lb | 1.4 | 0.8 | 2.4 |
| Biathlon | 200 lb | 0.8 | 0.8 | 1.3 |
| Biathlon | 400 lb | 1.3 | 0.3 | 0.0 |
| BroadStar | 150 lb | 0.8 | 0.9 | 0.7 |
| Gallery + Ronstar WSP | 1 lb + 2 lb | 0.6 | 1.1 | 2.1 |
| Untreated | -- | 1.2 | 1.2 | 1.2 |

*Hydrangea paniculata* 'Limelight'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT |
|---|---|---|---|---|
| Marengo G | 100 lb | 0.3 | 0.0 | 0.0 |
| Marengo G | 150 lb | 0.1 | 0.5 | 0.5 |
| Marengo G | 200 lb | 0.5 | 0.3 | 0.2 |
| Marengo G | 400 lb | 0.2 | 0.0 | 0.0 |
| Gallery + Barricade | 1.3 lb + 21 oz | 0.6 | 0.2 | 0.0 |
| Gallery + Surflan | 1.3 lb + 1 qt | 2.6 ** | 0.9 ** | 0.0 |
| Tower + Pendulum | 21 oz + 2 qt | 4.2 ** | 4.1 ** | 2.7 ** |
| Tower + Pendulum | 1 qt + 1 qt | 3.7 ** | 3.7 ** | 0.8 ** |
| Biathlon | 100 lb | 0.2 | 0.0 | 0.0 |
| Biathlon | 200 lb | 0.6 | 0.0 | 0.0 |
| Biathlon | 400 lb | 1.1 ** | 0.0 | 0.0 |
| BroadStar | 150 lb | 0.8 | 0.6 | 0.0 |
| Gallery + Ronstar WSP | 1 lb + 2 lb | 1.7 ** | 0.3 | 0.0 |
| Untreated | -- | 0.0 | 0.0 | 0.0 |

z = weeks after treatment

y = visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = visual ratings followed by *, ** are significantly different from the control based on Dunnett's t-test ($\alpha$ = 0.10 and 0.05, respectively).

*Willoway Avon.* Marengo G at 100 lb/ac did not injure the four species evaluated, *Hydrangea macrophylla* 'Endless summer', *Hydrangea arborescens* 'Invincible spirit', rose (*Rosa* 'Knockout'), and Itea (*Itea* 'Little Henry') (Table 7). The Gallery + Surflan (1 lb + 1 qt) did cause significant injury to *Hydrangea macrophylla* (rating 3.8 and 4.8, at 2 (Fig. 8) and 4 WAT, respectively) (Table 7); however, there was no injure to *Rosa* 'Knockout'. This was a different result from other years and compared to North Branch nursery, where the Gallery + Surflan has been quite phytotoxic to Rose (Table 7). From early on in the trial, random chlorosis across all treatments in the rose was occurring (Fig. 9). We later found out from the nursery manager that the cause of the problem was nutritional. This nutritional issue did eventually spread to all the

species evaluated at both Willoway sites and resulted in our not conducting evaluation past 4 WAT.

**Fig. 8.** (Left) From left to right *Hydrangea macrophylla* 'Endless summer' control, Tower + Pendulum (21 oz + 2 qt/ ac) 2 WAT and Gallery + Surflan (1 lb + 1 qt) (rating 3.8).

**Fig. 9.** (Left) *Rosa* 'Knockout' 2 WAT showing random leaf chlorosis across all species that was not related to any herbicide at Willoway Nursery, Avon, OH.

Tower + Pendulum at (21 oz + 2 qt/ ac) and (1 qt/ac + 1qt/ac) caused significant injury to *Hydrangea macrophylla* 'Endless summer', *Hydrangea arborescens* 'Invincible spirit' and rose (*Rosa* 'Knockout'). The Itea (*Itea* 'Little Henry') was the only species not injured by the Tower + Pendulum. Injury to rose was not as severe as with the two Hydrangea species and was considered commercially acceptable throughout the trial period.




**Fig. 10 A, B and C. A.** (above – left) *Hydrangea macrophylla* 'Endless summer' Tower + Pendulum (21 oz + 2 qt/ ac) 2 WAT and **B.** (above - right) Tower + Pendulum (1 qt + 1 qt/ac). **C** (left) *Hydrangea arborescens* 'Invincible spirit' Tower + Pendulum (21 oz + 2 qt/ ac) 2 WAT at Willoway Nursery, Avon, OH.

Biathlon at 100 lb/ac and FreeHand at 150 lb/ac were increasingly injurious only to the *Hydrangea arborescens* reaching commercially unacceptable by 4 WAT (Table 7). Regal O-O at 100 lb/ac severely injured the *Hydrangea arborescens* on all dates. None of the species were affected by the Jewel.


**Fig. 11 (A and B).** (Above) A. Regal O-O at 100 lb/ac causing severe injury (rating 5.9) 2 WAT on *Hydrangea arborescens* 'Invincible spirit'. B. From left to right control and FreeHand at 150 lb/ac 2 WAT (rating 2.3) at Willoway Nursery, Avon, Ohio.

**Table 7.** Phytotoxicity on selected ornamentals from several herbicides at Willoway Nurseries, Avon, OH trial was initiated on April 19, 2013 with the exception of the *Hydrangea macrophylla* 'Endless summer' which needed to be retreated on May 1, 2013 due to a severe frost event that occurred after the April 19 applications.

*Hydrangea arborescens* 'Invincible spirit'

| Treatment | Rate/ac | 1 WAT[z] | 2 WAT | 4 WAT |
|---|---|---|---|---|
| Marengo G | 100 lb | 0.0[yx] | 1.5 | 1.7 |
| Gallery + Surflan | 1 lb + 1 qt | 0.8 | 2.1 | 2.1 |
| Tower + Pendulum | 21 oz + 2 qt | 1.8 ** | 3.9 ** | 4.4 ** |
| Tower + Pendulum | 1 qt + 1 qt | 2.3 ** | 3.6 * | 4.8 ** |
| Biathlon | 100 lb | 0.6 | 2.5 | 3.4 * |
| FreeHand | 150 lb | 0.7 | 2.3 | 3.1 |
| Regal O-O | 100 lb | 4.0 ** | 5.9 ** | 5.0 ** |
| Jewel | 100 lb | 0.5 | 0.0 | 0.7 |
| Untreated | -- | 0.0 | 1.1 | 0.9 |

*Rosa* 'Knockout'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT |
|---|---|---|---|---|
| Marengo G | 100 lb | 0.0 | 0.0 | 1.1 |
| Gallery + Surflan | 1 lb + 1 qt | 0.8 * | 1.6 ** | 0.8 |
| Tower + Pendulum | 21 oz + 2 qt | 1.7 | 1.7 ** | 2.6 ** |
| Tower + Pendulum | 1 qt + 1 qt | 0.9 | 1.6 ** | 2.4 ** |
| Biathlon | 100 lb | 0.0 | 0.0 | 0.3 |
| FreeHand | 150 lb | 0.0 | 0.0 | 0.4 |
| Regal O-O | 100 lb | 0.5 | 0.0 | 1.2 |
| Jewel | 100 lb | 0.0 | 0.0 | 0.7 |
| Untreated | -- | 0.0 | 0.0 | 1.0 |

*Hydrangea macrophylla* 'Endless Summer'

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT |
|---|---|---|---|---|
| Marengo G | 100 lb | 0.6 | 0.0 | 0.1 |
| Gallery + Surflan | 1 lb + 1 qt | 1.8 ** | 3.8 ** | 4.8 ** |
| Tower + Pendulum | 21 oz + 2 qt | 1.8 ** | 4.2 ** | 5.3 ** |
| Tower + Pendulum | 1 qt + 1 qt | 1.1 | 2.7 ** | 4.0 ** |

| | | | | |
|---|---|---|---|---|
| Biathlon | 100 lb | 0.9 | 0.2 | 0.3 |
| FreeHand | 150 lb | 0.3 | 0.8 | 1.2 |
| Regal O-O | 100 lb | 1.0 | 0.3 | 0.0 |
| Jewel | 100 lb | 1.0 | 1.1 | 0.5 |
| Untreated | -- | 0.6 | 0.3 | 0.8 |
| *Itea virginica* 'Little Henry' | | | | |
| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT |
| Marengo G | 100 lb | 0.0 | 0.7 | 0.3 |
| Gallery + Surflan | 1 lb + 1 qt | 0.0 | 0.0 | 0.0 |
| Tower + Pendulum | 21 oz + 2 qt | 0.0 | 1.0 | 0.0 |
| Tower + Pendulum | 1 qt + 1 qt | 0.0 | 0.0 | 0.0 |
| Biathlon | 100 lb | 0.0 | 0.0 | 0.2 |
| FreeHand | 150 lb | 0.0 | 2.2 ** | 0.6 ** |
| Regal O-O | 100 lb | 0.0 | 0.2 | 0.1 |
| Jewel | 100 lb | 0.0 | 0.0 | 0.0 |
| Untreated | -- | 0.0 | 0.2 | 0.0 |

z = weeks after treatment

y = visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = visual ratings followed by *, ** are significantly different from the control based on Dunnett's t-test ($\alpha$ = 0.10 and 0.05, respectively).

**Field studies**.

*Studebaker Nurseries.* None of the treatments were phytotoxic to either *Buxus* 'Green velvet' or *Taxus densiformus* at any evaluation date (Table 8). All treatments provided commercially acceptable weed control ($\geq$ 7) at Studebaker Nurseries through 4 WAT. Only the V-10366 at 30 oz/ac was commercially acceptable 1 WA2T (Table 9) (Fig. 12). By the second application, there was severe weed pressure at Studebaker Nurseries including Canada thistle, field bindweed and many of the weeds listed in Table 2, including musk thistle which favor abandoned sites and is indicative of the severe weed pressure at Studebaker Nurseries (Fig. 13).

**Fig. 12.** *Buxus* 'Green velvet' providing commercially acceptable weed control ($\geq$ 7) at Studebaker Nurseries, New Carlisle, OH at 1 WA2T with V-10366 at 30 oz/ac.

**Fig. 13.** (Left) *Buxus* 'Green velvet' field at Studebaker Nurseries, New Carlisle, OH at 1 WA2T showing severe weed pressure including many of the weeds in Table 2 including musk thistle (below) which favors abandoned sites.

**Table 8.** Phytotoxicity on selected ornamentals from several herbicides at Studebaker Nurseries, New Carlisle, OH trial was initiated on May 6, 2013.

*Buxus* 'Green velvet'

| Treatment | Rate/ac | 1 WAT[z] | 2 WAT | 4 WAT | 1 WA2T |
|---|---|---|---|---|---|
| V-10336 | 7.5 oz | 0.8[yx] | 0.5 | 0.3 | 0.6 |
| V-10336 | 15 oz | 0.7 | 0.3 | 1.3 | 1.7 |
| V-10336 | 30 oz | 0.6 | 0.3 | 0.7 | 0.8 |
| Tower + Pendulum | 32 oz + 2 qt | 0.0 | 0.0 | 0.0 | 0.0 |
| SureGuard | 12 oz | 0.0 | 0.0 | 0.8 | 0.8 |
| SureGuard | 6 oz | 0.8 | 0.7 | 1.8 | 1.9 |
| Untreated | -- | 0.4 | 0.3 | 0.3 | 0.6 |

*Taxus densiformus*

| Treatment | Rate/ac | 1 WAT | 2 WAT | 4 WAT | 1 WA2T |
|---|---|---|---|---|---|
| V-10336 | 7.5 oz | 0.0 | 0.0 | 0.8 | 1.0 |
| V-10336 | 15 oz | 0.8 ** | 0.1 | 0.0 ** | 0.0 ** |
| V-10336 | 30 oz | 0.0 | 0.2 | 1.1 | 1.4 |
| Tower + Pendulum | 32 oz + 2 qt | 0.0 | 0.0 | 0.2 * | 0.3 * |
| SureGuard | 12 oz | 0.0 | 0.2 | 0.4 * | 0.5 ** |
| SureGuard | 6 oz | 0.0 | 0.0 | 0.5 | 1.0 |
| Untreated | -- | 0.0 | 0.1 | 1.5 | 2.1 |

z = weeks after treatment

y = Phytotoxicity visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = Treatment means followed by *,** are significantly different from the untreated control for that date (α = 0.10 and 0.05, respectively).

**Table 9.** Efficacy with several herbicides at Studebaker Nurseries, New Carlisle, OH trial was initiated on May 6, 2013.

| Weed control Treatment | Rate/ac | 1 WAT | | 2 WAT | | 4 WAT | | 1 WA2T |
|---|---|---|---|---|---|---|---|---|
| V-10336 | 7.5 oz | 10.0[wv] | a | 9.6 | ab | 8.8 | bc | 5.4 |
| V-10336 | 15 oz | 10.0 | a | 9.8 | ab | 9.5 | ab | 6.4 |
| V-10336 | 30 oz | 10.0 | a | 9.9 | a | 10.0 | a | 7.5 |
| Tower + Pendulum | 32 oz + 2 qt | 9.5 | b | 7.7 | c | 8.4 | cd | 5.9 |
| SureGuard | 12 oz | 10.0 | a | 9.7 | ab | 9.5 | ab | 6.0 |
| SureGuard | 6 oz | 9.9 | a | 9.1 | b | 9.3 | abc | 4.2 |
| Untreated | -- | 9.2 | c | 7.8 | c | 7.7 | d | 1.4 |

w = Weed control ratings based on a 0-10 scale with 0 being no weed control and 10 perfect weed control with ≥7 commer

v = Treatment means followed by the same letter in the same column are not significantly different based on lsmeans (α =

*North Branch Nursery.* All treatments were safe on the *Pinus strobus* and *Picea glauca*. Canada thistle, spiny sowthistle, yellow nutsedge, and prickly lettuce were the main weeds. The *Pinus strobus* was hoed prior to the second application, while *Picea glauca* was not. Therefore, only in the *Pinus strobus* were there two treatments that provided commercially acceptable weed control over all dates (Table 10). Biathlon was the best treatment for weed control in each species averaged across dates with a 7.8 rating in *Pinus strobus* and 5.0 rating in the *Picea glauca* (Fig. 14) (Table 10). Marengo also provided commercially acceptable weed control across all dates in the *Pinus strobus* (rating 7.3) (Table 10). V-10366 at 15 oz/ac provided comparable control to the non-treated (control plots) across all dates (Fig. 15) in pine (Table 10). Biathlon, however, was more capable of suppressing Canada thistle, which is why it had the highest ratings in both species (Table 10).


**Fig. 14**. **A and B**. **A.** (left) Note the region behind the first *Picea glauca* in the foreground where Biathlon was applied at North Branch Nursery, 4WAT compared to **B.** (below) Control plot in *Picea glauca.* Note the severe Canada thistle infestation on the control.


**Fig. 15. A and B**. **A.** (above) Note the region behind the first *Pinus strobus* in the foreground where V-10366 at 15 oz/ ac was applied at North Branch Nursery, 4WAT compared to **B.** Control plot in *Pinus strobus.* Note the control with V-10336 at 15 oz/ ac was comparable to the un-treated plots over all dates.

**Table 10.** Phytotoxicity and efficacy (weed control) on selected ornamentals with several herbicides at North Branch Nursery, Pemberville, OH the trial was initiated on April 23, 2013 averaged across 6 dates of evaluation with reapplication at 6 WAT and evaluations being conducted to 4 WA2T.

| | | *Pinus strobus* | | | | *Picea glauca* | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | Rate/ac | Phytotoxicity[z] | | Weed control | | Phytotoxicity | | Weed control | |
| Gallery + Barricade | 1.3 lb + 21 oz | 0.0[y] | no diff | 2.0[xw] | cd | 1.3 | no diff | 1.8 | b |
| Tower + Pendulum | 21 oz + 2 qt | 1.3 | no diff | 6.3 | ab | 0.1 | no diff | 2.5 | ab |
| Tower + Pendulum | 1 qt + 1 qt | 0.5 | no diff | 4.0 | bc | 1.2 | no diff | 2.3 | ab |
| Biathlon | 100 lbs | 0.1 | no diff | 7.8 | a | 0.3 | no diff | 5.0 | a |
| Marengo G | 150 lbs | 0.6 | no diff | 7.3 | ab | 0.3 | no diff | 3.5 | ab |
| V-10336 | 15 oz | 0.5 | no diff | 2.5 | cd | 0.4 | no diff | 3.5 | ab |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SureGuard | 6 oz | 0.6 | no diff | 1.5 | d | 0.0 | no diff | 2.0 | b |
| Untreated | -- | 0.8 | no diff | 2.3 | cd | 0.0 | no diff | 2.0 | b |

z = Phytotoxicity and weed control ratings are averaged over all evaluation dates

y = Phytotoxicity visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

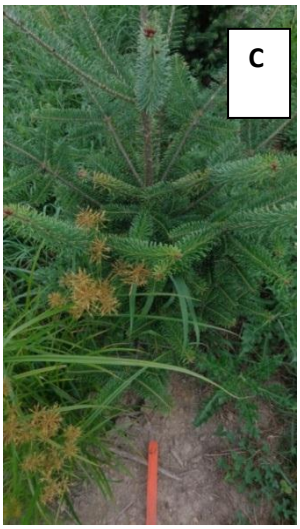
x = Weed control ratings based on a 0-10 scale with 0 being no weed control and 10 perfect weed control with ≥7 commercially acceptable

w = Treatment ratings followed by the same letter in the same column are not significantly different based on lsmeans ($\alpha = 0.05$)

*Timbuk Farms.* With the newly planted Canaan Fir, Abies *balsamea* var phanerolepis also known as West Virginia Fir trees, Tower + Pendulum at 21 oz + 2 qt (Fig. 16 A), V-10366 at 15 oz/ac (Fig. 16 B) and SureGuard at 6 oz/ac (Fig. 16 C) caused significant, non- commercially acceptable injury (Table 11). The most phytotoxic treatment was the V-10366 on the newly planted trees (Table 11). The Tower + Pendulum at 21 oz + 2 qt and SureGuard injury, on the newly planted trees, were after the second application (Table 11). The V-10366 injury was after the first and second application (Table 11).

On the three year old trees the V-10366 at 15 oz/ac again caused the most injury; however, the injury occurred after the second application (Table 11). The Tower + Pendulum at 21 oz + 2 qt also became injurious at non-commercially acceptable levels after the second application to the three year old trees (Table 11). The addition of 1 qt of pendulum caused increased injury with both stages of Canaan fir. This was opposite to the container trial at North Branch where the increase in Tower caused more injury but a similar result to Willoway, Huron, OH where the higher rate of pendulum increased injury on *Azalea* and *Hydrangea*.


**Fig. 16 A, B and C. A**. (left) Newly planted *Abies balsamea* var phanerolepis, Canaan fir applied with Tower + Pendulum at 21 oz + 2 qt with significant, non- commercially acceptable injury 1WA2T at Timbuk Farms, Granville, OH; **B.** (below-left) applied with SureGuard 6 oz/ac. and **C.** (below – right) applied with V-10366 15 oz/ac.


Commercially acceptable (≥ 7) weed control occurred with all treatments until 1 WA2T averaged across dates (Table 12). At 1 WA2T Tower + Pendulum (21 oz + 2 qt) (Fig. 16 A) (1 qt + 1 qt); V-10366 at 15 oz/ac (Fig. 16 C); and SureGuard at 6 oz/ac (Fig. 16 B) were still providing commercially acceptable efficacy across dates (Table 12). Weed pressure was quite severe in the untreated plots by 1 WA2T (Fig. 17). By 2 WA2T, only Tower + Pendulum (21 oz + 2 qt), V-10366 and SureGuard were commercially acceptable across dates (Table 12). V-10366 at 15 oz/ac was the best treatment overall and Gallery + Barricade was the worst treatment for weed control (Table 12).

**Fig. 17.** Newly planted *Abies balsamea* var phanerolepis, Canaan fir showing untreated plot with severe weed pressure 1 WA2T at Timbuk Farms, Granville, OH.

**Table 11.** Phytotoxicity on two different sizes of field grown Canaan fir Christmas trees from several herbicides at Timbuk Farms, Granville, OH trial was initiated on July 9, '13.

| First year Canaan fir Treatment | Rate/ac | 1 WAT[z] | 2 WAT | 3 WAT | 4 WAT | 1 WA2T | 2 WA2T |
|---|---|---|---|---|---|---|---|
| Gallery + Barricade | 1.3 lb + 21 oz | 0.6[yx] | 0.0 | 0.8 | 0.6 | 2.9 | 2.8 |
| Tower + Pendulum | 21 oz + 2 qt | 0.5 | 0.9 | 1.4 | 0.9 | 3.3 * | 3.3 ** |
| Tower + Pendulum | 1 qt + 1 qt | 1.2 | 0.2 | 1.0 | 0.0 | 2.3 | 2.5 |
| Biathlon | 100 lbs | 0.8 | 0.6 | 0.5 | 0.0 | 0.9 | 0.9 |
| Marengo G | 150 lbs | 0.8 | 0.6 | 0.5 | 0.0 | 1.4 | 1.1 |
| V-10366 | 15 oz | 3.4 ** | 3.0 ** | 2.6 | 2.5 * | 5.8 ** | 6.5 ** |
| SureGuard | 6 oz | 1.3 | 1.1 | 1.3 | 0.1 | 2.8 | 3.0 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Untreated | -- | 1.4 | | 0.5 | | 1.3 | | 0.3 | | 0.3 | | 0.4 | |
| 3 year Canaan fir | | | | | | | | | | | |
| Treatment | Rate/ac | 1 WAT | | 2 WAT | | 3 WAT | | 4 WAT | | 1 WA2T | | 2 WA2T | |
| Gallery + Barricade | 1.3 lb + 21 oz | 0.0 | | 0.0 | | 0.4 | | 0.1 | | 1.6 | | 2.1 | |
| Tower + Pendulum | 21 oz + 2 qt | 0.0 | | 0.0 | | 0.0 | | 1.5 | | 3.9 | | 3.1 | |
| Tower + Pendulum | 1 qt + 1 qt | 0.7 | | 0.5 | | 0.0 | | 0.0 | | 1.5 | | 1.5 | |
| Biathlon | 100 lbs | 0.0 | | 0.0 | | 0.0 | | -0.1 | | 0.1 | | 0.3 | |
| Marengo G | 150 lbs | 4.1 | ** | 0.0 | | 0.0 | | 0.4 | | 0.5 | | 0.6 | |
| V-10366 | 15 oz | 0.0 | | 0.4 | | 1.8 | ** | 2.5 | ** | 4.5 | ** | 4.4 | |
| SureGuard | 6 oz | 0.0 | | 0.0 | | 0.0 | | 0.0 | | 1.5 | | 1.4 | |
| Untreated | -- | 0.0 | | 0.3 | | 0.4 | | 0.0 | | 1.3 | | 1.5 | |

z = weeks after treatment

y = phytotoxicity visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = treatment means followed by *,** are not significantly different from the untreated control at that evaluation date based on Dunnett's t-test (α = 0.10 and 0.05, respectively)

**Table 12.** Efficacy across two ages of field grown Canaan fir Christmas trees from several herbicides at Timbuk Farms, Granville, OH trial was initiated on July 9, 2013.

| Treatment | Rate/ac | 1 WAT[z] | | 2 WAT | | 3 WAT | | 4 WAT | | 1 WA2T[y] | | 2 WA2T | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gallery + Barricade | 1.3 lb + 21 oz | 9.3[xw] | ab | 8.4 | b | 9.3 | abc | 7.8 | c | 6.3 | c | 5.6 | d |
| Tower + Pendulum | 21 oz + 2 qt | 9.1 | b | 8.9 | ab | 9.4 | abc | 8.8 | abc | 7.3 | abc | 7.2 | ab |
| Tower + Pendulum | 1 qt + 1 qt | 9.4 | ab | 8.9 | ab | 9.1 | bc | 8.2 | bc | 7.0 | abc | 6.7 | bc |
| Biathlon | 100 lbs | 9.5 | ab | 8.8 | ab | 9.2 | abc | 9.3 | a | 6.7 | bc | 6.1 | cd |
| Marengo G | 150 lbs | 9.7 | a | 8.8 | ab | 9.3 | abc | 9.1 | ab | 6.8 | bc | 6.1 | cd |
| V-10366 | 15 oz | 9.6 | a | 9.7 | a | 9.8 | ab | 9.3 | a | 8.2 | a | 8.1 | a |
| SureGuard | 6 oz | 9.7 | a | 9.5 | a | 9.9 | a | 9.7 | a | 7.6 | ab | 7.5 | ab |
| Untreated | -- | 9.4 | ab | 9.0 | ab | 9.0 | c | 8.2 | bc | 3.8 | d | 3.8 | e |

z = weeks after treatment

y = weeks after second treatment

x = weed control ratings based on a 0-10 scale with 0 being no weed control and 10 perfect weed control with ≥7 commercially acceptable

w = treatment means followed by the same letter in the same column are not significantly different based on lsmeans (α = 0.05)

**Liverwort Results.**

WeedPharm was phytotoxic to boxwood, *Buxus microphylla* 'Winter gem' after the first application (Fig. 18) (Table 13). WeedPharm became phytotoxic to barberry, *Berberis* 'Orange Rocket' (Fig. 19); hydrangea, *Hydrangea arborescens* 'Incrediball'; and, Physocarpus 'Summer wine' after the second application (Fig. 22) (Table 13). SureGuard did not cause commercially unacceptable injury (≤3) to any of the species until after the second application. The 4 oz/ac rate was consistently more phytotoxic than the 3 oz/ac (Table 13) with *Hydrangea arborescens* 'Incrediball' being almost completely killed with the 4 oz/ac rate (Table 13) (Fig. 20). Marengo was phytotoxic only to *Berberis* 'Orange Rocket' after the first application (Table 13). Marengo, like SureGuard, had increased phytotoxicity after the second application on all species, severely so on *Hydrangea arborescens* 'Incrediball' (Fig. 21) and *Physocarpus* 'Summer wine' ( Fig. 22)

(Table 13). The potassium bicarbonate (2.24 g/ft3) had the least amount of phytotoxicity in this study and never reached commercially acceptable injury even after the second application (Table 13). The only exception was *Hydrangea arborescens* 'Incrediball' at 12 WAT (rating 6.7). The untreated control also developed a high visual rating (5.0) at 12 WAT. It is probable the injury attributed to the potassium bicarbonate on hydrangea at 12 WAT was not a treatment effect. The baking soda (2.24 g/ft$^3$) had low phytotoxicity on all species until 12 WAT on *Physocarpus* 'Summer wine' (Table 13). The baking soda (2.24 g/ft$^3$) also became very phytotoxic with the *Hydrangea arborescens* 'Incrediball' at 12 WAT (rating 7.3) (Table 13). As with the potassium bicarbonate on hydrangea at 12 WAT, the high visual rating (5.0) at 12 WAT in the untreated control leads us to believe the injury was not a treatment effect. All treatments controlled liverwort very well; however, liverwort pressure was generally low (data not shown). SureGuard and Marengo provided excellent efficacy and low phytotoxicity as dormant applications; however, most species are sensitive to these products during bud break and after active growth is occurring. Baking soda, however, can be used during both dormant and active growth. The best combination for residual liverwort control would be to use SureGuard 3 oz/ac dormant or Marengo 9 oz/ac. followed by baking soda or K-bicarbonate applications in the active growth, as required. We recommend more work on these combinations to determine optimum rates and timings.

**Fig. 18.** (Left) *Buxus microphylla* 'Winter gem' from left to right control versus WeedPharm 10% v/v at 2 WAT at Decker's Nursery, Groveport, OH.

**Fig. 19.** (Left) *Berberis* 'Orange Rocket' from

left to right WeedPharm 10% v/v versus control at 9 WAT or 1 WA2T at Decker's Nursery, Groveport, OH.

**Fig. 20.** (Left) *Hydrangea arborescens* 'Incrediball' 9 WAT with SureGuard 4 oz/ac at Decker's Nursery, Groveport, OH.

**Fig. 21.** (Left) *Hydrangea arborescens* 'Incrediball' 9 WAT with Marengo 9 oz/ac at Decker's Nursery, Groveport, OH.

**Fig. 22.** (Left) *Physocarpus* 'Summer wine' 9 WAT from left

to right WeedPharm 10% v/v, Marengo 9 oz/ac and control at Decker's Nursery, Groveport, OH.

**Table 13.** Liverwort control trials were initiated at Decker's Nursery, Inc., Groveport, OH on February 28, 2013 in a covered hoop house that had minimum heat. Several herbicides were evaluated for their phytotoxicity on four crops with particular susceptibility to liverwort infestation. Reapplications were made on April 26, 2013 or 6 WAT.

*Berberis* 'Orange Rocket'

| Treatment | Rate | 1 WAT[z] | 2 WAT | 4 WAT | 8 WAT | 9 WAT | 10 WAT | 12 WAT |
|---|---|---|---|---|---|---|---|---|
| SureGuard | 3 oz/ac | 0.0[x] | 0.0 | 1.4 ** | 0.0 | 1.7 ** | 2.0 ** | 3.0 ** |
| SureGuard | 4 oz/ac | 0.0 | 0.0 | 1.9 ** | 0.0 | 2.6 ** | 2.7 ** | 4.0 ** |
| Baking soda | 2.24 g/ft$^2$ | 0.0 | 0.0 | 0.0 | 1.0 ** | 0.2 | 0.1 | 0.1 |
| K-bicarbonate | 2.24 g/ft$^3$ | 0.0 | 0.0 | 2.9 ** | 0.0 | 0.0 | 0.0 | 0.0 |
| WeedPharm | 10% v/v | 0.0 | 0.0 | 2.0 ** | 0.0 | 8.7 ** | 7.7 ** | 2.8 ** |
| Marengo SC | 9 oz/ac | 0.0 | 0.0 | 3.3 ** | 0.2 | 5.0 ** | 5.1 ** | 5.3 ** |
| Untreated | -- | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

*Buxus macrophylla*

| Treatment | Rate | 1 WAT | 2 WAT | 4 WAT | 8 WAT | 9 WAT | 10 WAT | 12 WAT |
|---|---|---|---|---|---|---|---|---|
| SureGuard | 3 oz/ac | 0.8 | 0.4 | 1.2 | 0.0 | 1.4 ** | 2.6 ** | 3.0 ** |
| SureGuard | 4 oz/ac | 0.7 | 0.6 | 0.7 | 0.2 | 0.9 | 3.1 ** | 3.0 ** |
| Baking soda | 2.24 g/ft$^2$ | 0.4 | 0.0 | 1.4 | 0.0 | 1.1 * | 2.0 ** | 2.0 ** |
| K-bicarbonate | 2.24 g/ft$^3$ | 1.3 | 1.1 | 1.3 | 0.2 | 0.3 | 1.4 ** | 1.0 ** |
| WeedPharm | 10% v/v | 2.9 ** | 6.0 ** | 5.2 ** | 5.3 ** | 5.7 ** | 6.4 ** | 5.8 ** |
| Marengo SC | 9 oz/ac | 0.7 | 0.7 | 1.3 | 0.0 | 1.0 | 3.1 ** | 3.0 ** |
| Untreated | -- | 0.6 | 0.6 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 |

*Hydrangea arborescens*

| Treatment | Rate | 1 WAT | 2 WAT | 4 WAT | 8 WAT | 9 WAT | 10 WAT | 12 WAT |
|---|---|---|---|---|---|---|---|---|
| SureGuard | 3 oz/ac | 0.0 | 0.0 | 0.0 | 2.1 | 8.0 ** | 8.0 ** | 4.9 |
| SureGuard | 4 oz/ac | 0.0 | 0.0 | 0.0 | 2.0 | 9.8 ** | 9.3 ** | 9.9 ** |
| Baking soda | 2.24 g/ft$^2$ | 0.0 | 0.0 | 0.0 | 0.1 | 1.7 ** | 2.9 ** | 7.3 ** |
| K-bicarbonate | 2.24 g/ft$^3$ | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 1.0 | 6.7 ** |
| WeedPharm | 10% v/v | 0.0 | 0.0 | 0.0 | 2.0 | 7.2 ** | 8.1 ** | 4.9 |
| Marengo SC | 9 oz/ac | 0.0 | 0.0 | 0.0 | 5.6 ** | 6.9 ** | 8.7 ** | 9.6 ** |
| Untreated | -- | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.0 |

*Physocarpus 'Summer wine'*

| Treatment | Rate | 1 WAT | 2 WAT | 4 WAT | 8 WAT | 9 WAT | 10 WAT | 12 WAT |
|---|---|---|---|---|---|---|---|---|
| SureGuard | 3 oz/ac | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 ** | 1.0 ** | 3.0 ** |
| SureGuard | 4 oz/ac | 0.0 | 0.0 | 0.0 | 0.0 | 1.7 ** | 0.0 | 2.8 ** |
| Baking soda | 2.24 g/ft$^2$ | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 ** | 1.0 ** | 3.6 ** |
| K-bicarbonate | 2.24 g/ft$^3$ | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 1.0 ** |
| WeedPharm | 10% v/v | 0.0 | 0.0 | 0.0 | 0.0 | 7.8 ** | 8.3 ** | 4.4 ** |
| Marengo SC | 9 oz/ac | 0.0 | 0.0 | 0.0 | 0.0 | 4.6 ** | 7.9 ** | 5.8 ** |
| Untreated | -- | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

z = weeks after treatment

y = visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially accept

x = visual ratings followed by *, ** are significantly different from the control based on Dunnett's t-test (α = 0.1

**Difficult weeds. Rorippa trial.**

*Preemergence trial.* Trials to control *Rorippa sylvestris* (creeping yellow cress) preemergence in *Syringa vulgaris* liner fields resulted in Corsair, Certainty, and SedgeHammer providing perfect efficacy through 8 WAT (Table 15). Corsair provided the highest efficacy at 11 WAT and was the only treatment that was significantly better than the untreated controls (Table 15). Lontrel provided little to no preemergence efficacy for creeping yellow cress. This is not surprising, as Lontrel is not labeled as a preemergence herbicide. V-10336 provided excellent control through 5 WAT; however, by 6 WAT, efficacy decreased to a rating of 5.5, only slightly better than untreated (Table 15).

Phytotoxicity varied among the treatments (Table 14). Corsair, although extremely efficacious, was also extremely phytotoxic. BY 11 WAT, all the lilacs were dead in the Corsair plots (Table 14). V-10336 at 15 oz/ac was also very phytotoxic to lilac by 11 WAT (Table 14). V-10336 became more phytotoxic as the trial progressed (Table 14), even though it was applied during dormancy. Casoron also became increasingly phytotoxic over time and significantly so by 11 WAT (Table 14). We recommend Certainty and SedgeHammer be used in further studies for preemergence control of *Rorippa* in lilacs and other species as both showed promise in efficacy and reduced phytotoxicity.

**Table 14.** Phytotoxicity to *Syringa vulgaris* from selected preemergence applications applied April 4, 2013.

| Phytotoxicity Treatment | Rate/ac | 4 WAT[z] | 5 WAT | 6 WAT | 8 WAT | 11 WAT |
|---|---|---|---|---|---|---|
| Corsair | 5.3 oz | 7.5[yx] | 8.3 ** | 9.0 ** | 9.3 ** | 10.0 ** |
| Certainty | 1 oz | 4.5 | 4.5 | 5.5 | 6.5 | 5.0 |
| SedgeHammer | 2 oz | 5.3 | 5.3 | 6.3 * | 6.0 | 4.8 |
| Lontrel | 1 pt | 3.3 | 3.5 | 4.8 | 4.5 | 4.3 |
| V-10336 | 15 oz | 3.8 | 4.3 | 5.0 | 7.3 | 7.0 ** |
| Diuron | 3 lb | 2.0 | 3.0 | 4.5 | 5.8 | 5.8 |
| Casoron + PN | 3 gal | 3.5 | 4.8 | 5.3 | 6.3 | 8.0 ** |
| Untreated | -- | 2.3 | 1.5 | 2.5 | 3.5 | 2.5 |

**Table 15.** Efficacy in *Syringa vulgaris* fields for *Rorippa sylvestris* (creeping yellow cress) from selected preemergence applications applied April 4, 2013.

| Creeping yellow field cress control | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | Rate/ac | 4 WAT | | 5 WAT | | 6 WAT | | 8 WAT | | 11 WAT | |
| Corsair | 5.3 oz | 9.0[wv] | a | 9.3 | a | 10.0 | a | 10.0 | a | 9.8 | a |
| Certainty | 1 oz | 10.0 | a | 9.5 | a | 10.0 | a | 10.0 | a | 8.8 | ab |
| SedgeHammer | 2 oz | 10.0 | a | 9.8 | a | 10.0 | a | 9.8 | a | 8.5 | abc |
| Lontrel | 1 pt | 2.8 | c | 3.3 | d | 6.8 | bcd | 7.0 | bc | 6.8 | bc |
| V-10336 | 15 oz | 9.5 | a | 7.5 | ab | 5.5 | cd | 2.5 | d | 5.8 | c |
| Diuron | 3 lb | 4.3 | bc | 6.3 | bc | 7.5 | bc | 7.8 | ab | 8.3 | abc |
| Casoron + PN | 3 gal | 6.3 | b | 8.0 | a | 7.8 | ab | 7.0 | bc | 9.0 | ab |
| Untreated | -- | 3.5 | c | 4.0 | cd | 5.0 | d | 4.8 | cd | 6.0 | bc |

*Note. For Table 14 and 15.*
z = weeks after treatment
y = Phytotoxicity ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable
x = Treatment ratings followed by *,** are significantly different from the control, based on Dunnett's t-test (α = 0.10 and 0.05, respectively)
w = Control ratings are based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable
v = Treatment ratings followed by the same letter in the same column are not significantly different based on lsmeans (α = 0.05)

*Postemergence trial.* All of the treatments caused greater phytotoxicity than the control (Table 16). Lontrel, however, was the only treatment where the injury was near commercially acceptable (Table 16). More work and trials need to be conducted to determine the best option for control of creeping yellow field cress in field situations.

Excellent efficacy was achieved with six of the eight treatments; Marengo SC and Lontrel were the only two treatments not providing acceptable control at 5 WAT (Table 17). Marengo was significantly better than the control at 2 WAT, but not 5 WAT (Table 17). Lontrel, although not commercially acceptable, provided better control than Marengo and the untreated plots and was similar to Diuron at 5 WAT (Table 17) Corsair, just like in the preemergence trial, provided the best control of *Rorippa*.

We recommend Lontrel be further studied for control of *Rorippa* as it was the only product to provide near acceptable phytotoxicity and some level of weed control. Although Lontrel's efficacy was not as high as some of the other products, it seems to be the only one with promise.

**Table 16.** Phytotoxicity to *Syringa vulgaris* from selected postemergence herbicide applications applie

| Phytotoxicity | | |
|---|---|---|
| Treatment | Rate/ac | 2 WAT[z] |
| Corsair | 5.3 oz | 6.0[yx] ** |
| Certainty | 1 oz | 4.8 ** |
| SedgeHammer | 2 oz | 6.0 ** |
| Classic | 2/3 oz | 6.5 ** |
| Lontrel | 1 pt | 3.8 ** |
| V-10336 | 15 oz | 9.0 ** |
| Diuron | 3 lb | 7.5 ** |
| Marengo SC | 9 oz | 4.3 ** |
| Untreated | -- | 1.0 |

**Table 17.** Efficacy in *Syringa vulgaris* fields for *Rorippa sylvestris* (creeping yellow cress) from selecte

| Creeping yellow field cress control | | | |
|---|---|---|---|
| Treatment | Rate/ac | 2 WAT | |
| Corsair | 5.3 oz | 9.0[wv] | a |
| Certainty | 1 oz | 9.0 | a |
| SedgeHammer | 2 oz | 8.8 | ab |
| Classic | 2/3 oz | 9.0 | a |
| Lontrel | 1 pt | 6.0 | c |
| V-10336 | 15 oz | 9.0 | a |
| Diuron | 3 lb | 6.5 | bc |
| Marengo SC | 9 oz | 6.8 | abc |
| Untreated | -- | 3.0 | d |

*Note: For table 16 and 17:*

z = weeks after treatment

y = Phytotoxicity ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially

x = Treatment ratings followed by *,** are significantly different from the control, based on Dunnett's t-test (α =

w = Control ratings are based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercial

v = Treatment ratings followed by the same letter in the same column are not significantly different based on lsm

From our pre- project start surveys we found that liner bed growers were using the following herbicides, Rout, Barricade, Snapshot, SureGuard, Pendulum, Round up, Goal, Tower, Lontrel and 2, 4-D. On average, they were spending $250.00/ac to hand weed problem areas with difficult weeds such as *Rorippa.* We had targeted to reduce their weed program cost by 30%. We accomplished this goal. The acceptable use of Lontrel in this study provided 35% control, thus reducing hand weeding costs by 35%.

**Table 18.** Summary of some herbicides and crops that experienced **no phytotoxicity** at the seven sites in 2013.

| Herbicide | No phytotoxicity | Comments |
|---|---|---|
| **Marengo G (100, 150, 200, 400 lb/ac)** | *Azalea* 'Karen' | |
| | *Pieris* 'Red Mill' | |
| | *Ilex* × *meserveae* 'Blue Maid' | |
| | Hemerocallis 'Stella d oro' | |
| | *Hydrangea paniculata* 'Limelight' | |
| | *Hydrangea paniculata* 'Little Lamb' | |
| | *Rhododendron* 'Nova Zembla' | |
| **Marengo (100 lb/ac)** | *Hydrangea arborescens* 'Invincibelle spirit' | |
| | *Hydrangea macrophylla* 'Endless Summer' | |
| | *Itea virginica 'Little Henry'* | |
| **Marengo G (100,200 lb/ac)** | *Viburnum X* 'Juddi' | |
| | *Buxus sempervirens* 'Vardar Valley' | |
| | *Taxus* X media 'Runyon' | |
| | *Rosa* 'Knockout' | |
| **Biathlon (100, 200, 400 lb/ac)** | *Azalea* 'Karen' | |
| | *Pieris* 'Red Mill' | |
| | *Ilex* × *meserveae* 'Blue Maid' | |
| | *Rhododendron* 'Nova Zembla' | |
| | *Hydrangea paniculata* 'Little Lamb' | |
| | *Viburnum* 'Juddi' | |
| **Biathlon (100 lb/ac)** | *Hydrangea macrophylla* 'Endless Summer' | |
| | *Itea virginica 'Little Henry'* | |
| | *Rosa* 'Knockout' | |
| | *Pinus strobus* | Field |
| | *Picea glauca* | Field |
| | Canaan fir (newly planted) | Field |
| | Canaan fir (3 yr. old) | Field |
| **Gallery + Surflan (1.3 lb + 1 qt/ac)** | *Azalea* 'Karen' | |

| | | |
|---|---|---|
| | *Pieris* 'Red Mill' | |
| | *Ilex* × *meserveae* 'Blue Maid' | |
| | *Hemerocallis* 'Stella d oro' | |
| | *Viburnum* 'Juddi' | |
| | *Hydrangea paniculata* 'Little Lamb' | |
| | *Rhododendron* 'Nova Zembla' | |
| | *Ilex* × *meserveae* 'Blue Maid' | |
| **Gallery + Surflan (1.3 lb + 1 qt/ac) and (1.3 lb + 2qt)** | *Buxus sempervirens* 'Vardar Valley' | |
| | *Taxus* X media 'Runyon' | |
| **Gallery + Barricade (1.3 lb + 21 oz)** | *Azalea* 'Karen' | |
| | *Pieris* 'Red Mill' | |
| | *Ilex* × *meserveae* 'Blue Maid' | |
| | *Viburnum X* 'Juddi' | |
| | *Hydrangea paniculata* 'Limelight' | |
| | *Hydrangea paniculata* 'Little Lamb' | |
| | *Rhododendron* 'Nova Zembla' | |
| | *Pinus strobus* | Field |
| | *Picea glauca* | Field |
| | *Canaan fir* (newly planted) | Field |
| | *Canaan fir* (3 yr. old) | Field |

**Beneficiaries:**

Beneficiaries from these trials are nursery and Christmas tree managers and staff at the six sites involved in the trials in Ohio. However, in 2013, 29 extension/ research presentations were also given with results from these trails. Sixteen of these were out-of-state and benefited 1000 attendees in MI, IN, OR, MD and MA. Thirteen were in-state presentations and benefited 2069 attendees from landscape, lawn care, nursery, arboriculture and garden center backgrounds. All of the out-of-state presentations were invited and were for industry organized events. This indicates the value and demand for this information to industry members. All of the in-state presentations were also invited with 75% organized by university, extension or government agencies indicated the high demand for the information from agencies that promote current information to their audiences. One technical report, two trade articles and one chapter in a manual for Christmas Tree Plantations regarding weed control were also produced with an expected outreach to 3000 people. In total we

reached over 5000 people in the Ohio nursery and Christmas tree industries and over 2000 out-of-state.

**Lessons Learned:**
In the proposal there was $9,000.00 budgeted for two flat rate contractors James Beaver and Randy Zondag. Neither Mr. Beaver nor Mr. Zondag was able to work on this project in 2013 and this portion of the project was allocated to Dr. Mathers of OSU and some is allocated to Luke Case of OSU. Dr. Mathers and Mr. Case performed all the work in this project. Due to loss of the contractors we required additional supplies and a new sprayer as equipment had to be purchased.

The $9,000 mentioned above for contractual was in error. The approved budgeted amount for contractual was $8,000 which was moved to personnel due to the staffing issues. There also was $1,213 moved from Travel to Supplies and Materials. Moving these two amounts totals $9,213 which is less than 25% of the award.

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